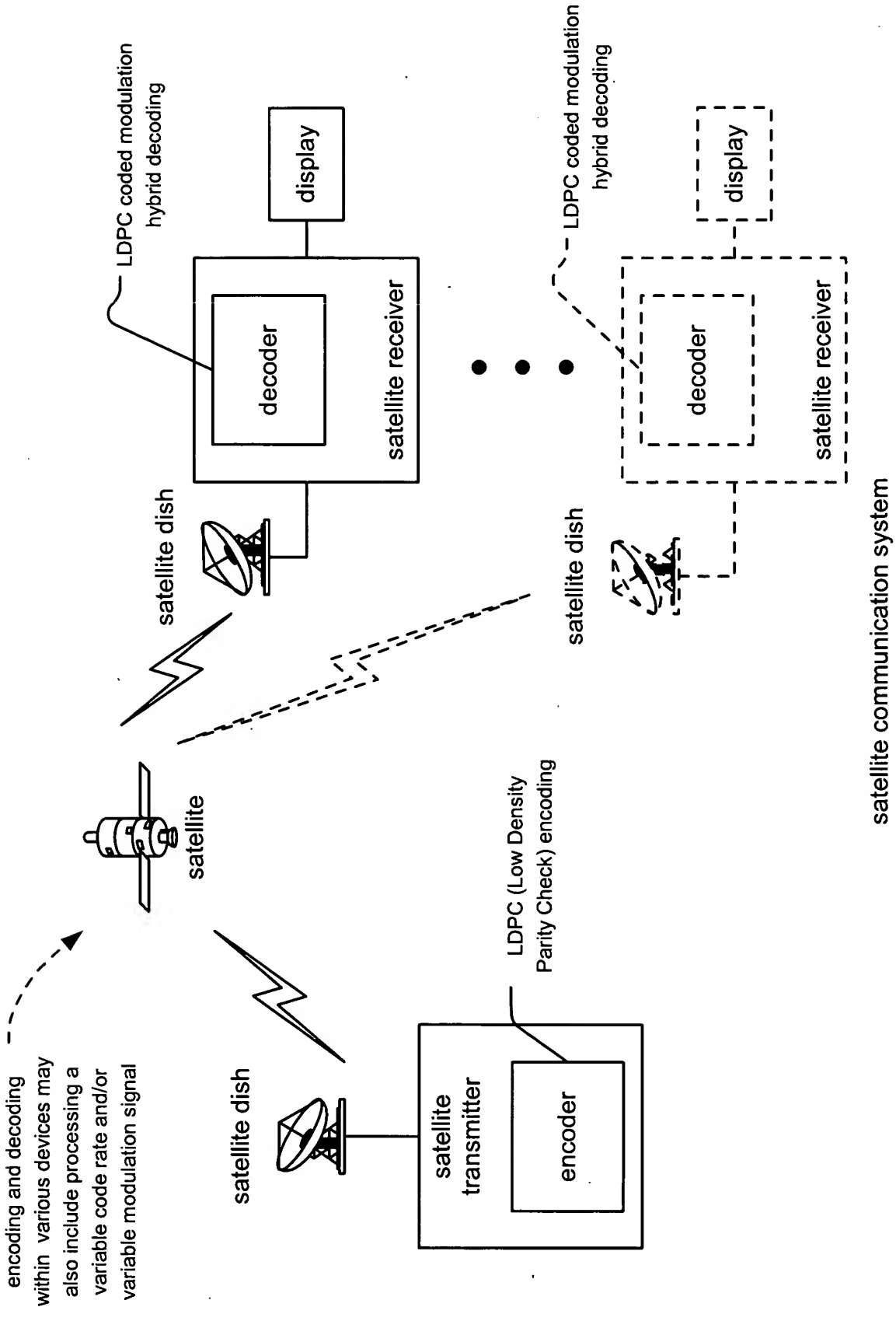
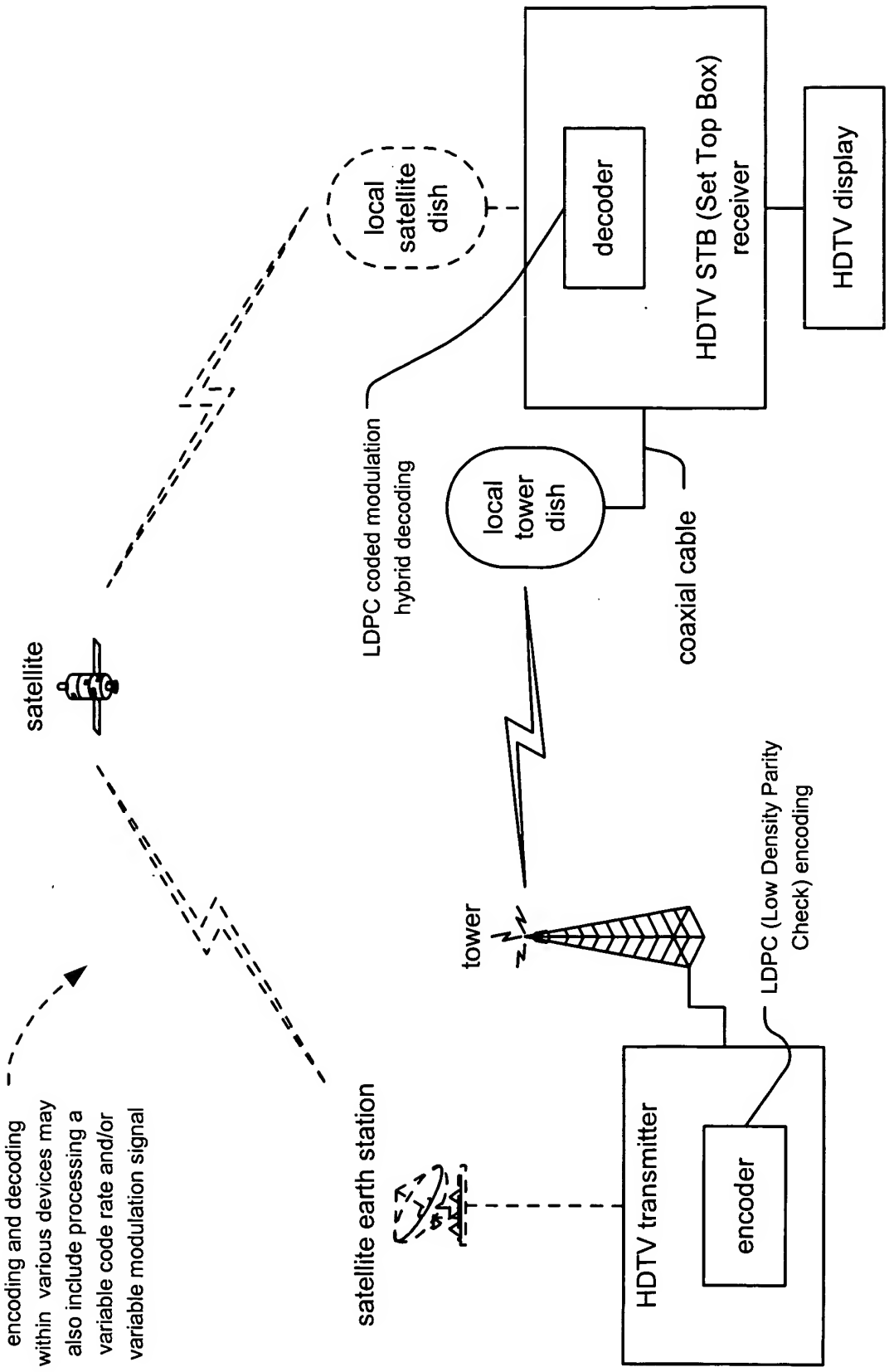
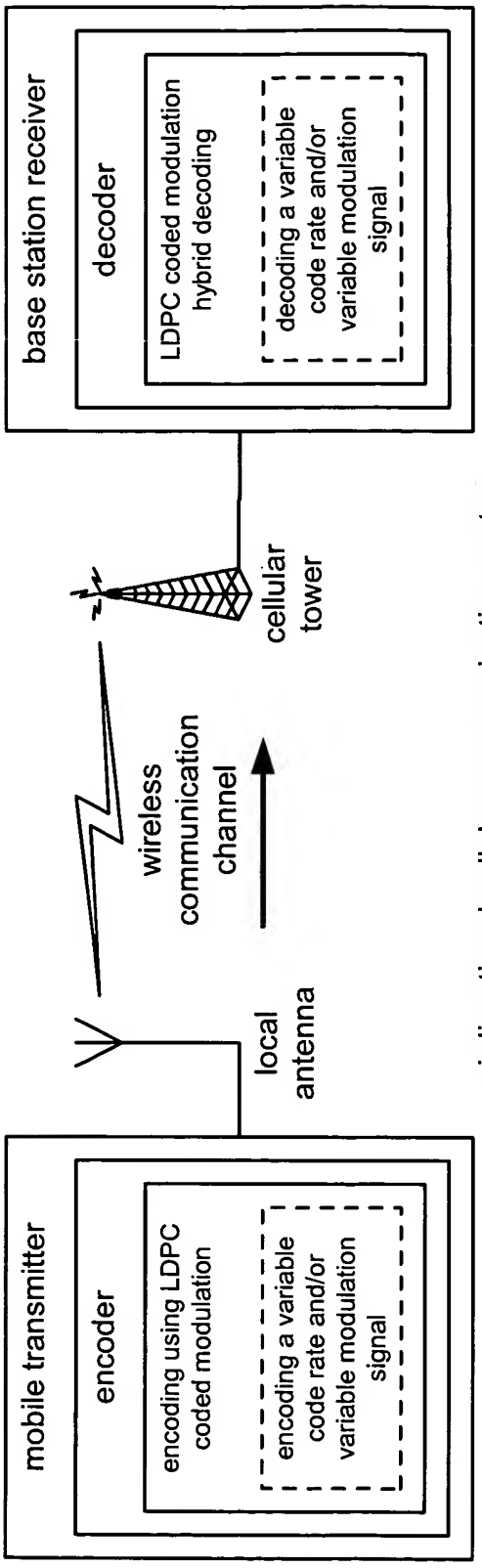

encoding and decoding within various devices may also include processing a variable code rate and/or variable modulation signal
satellite dish
satellite transmitter
encoder
LDPC (Low Density Parity Check) encoding
satellite
satellite dish
satellite dish
LDPC coded modulation hybrid decoding
decoder
satellite receiver
display
LDPC coded modulation hybrid decoding
decoder
satellite receiver
display
satellite communication system

Fig. 1



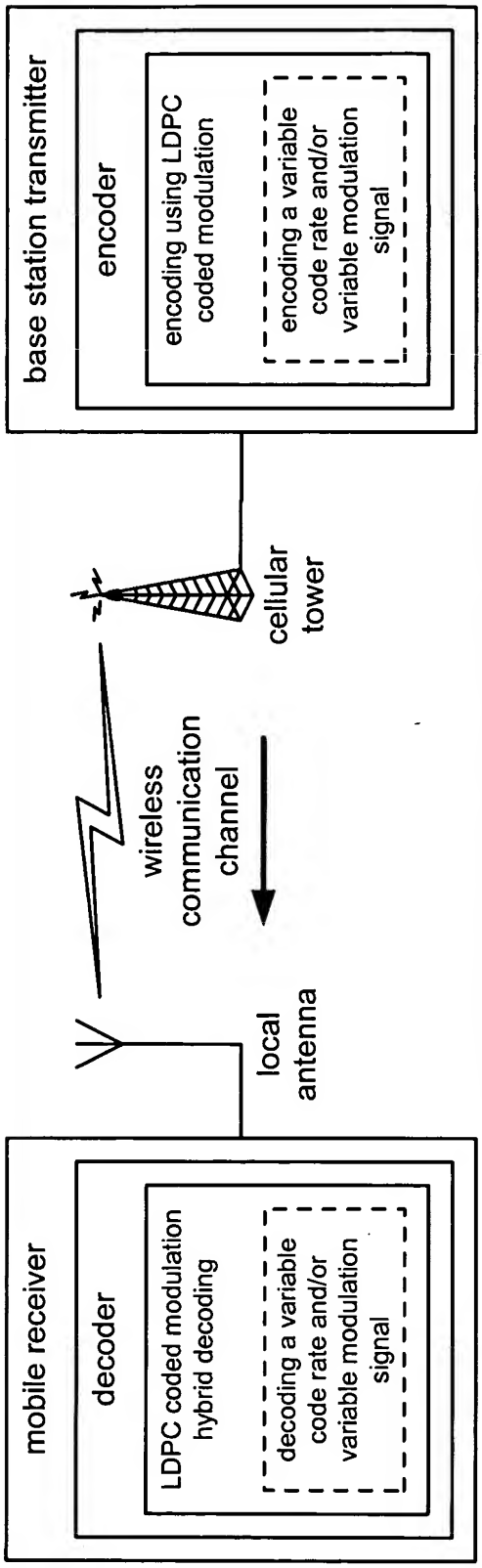
HDTV (High Definition Television) communication system

Fig. 2



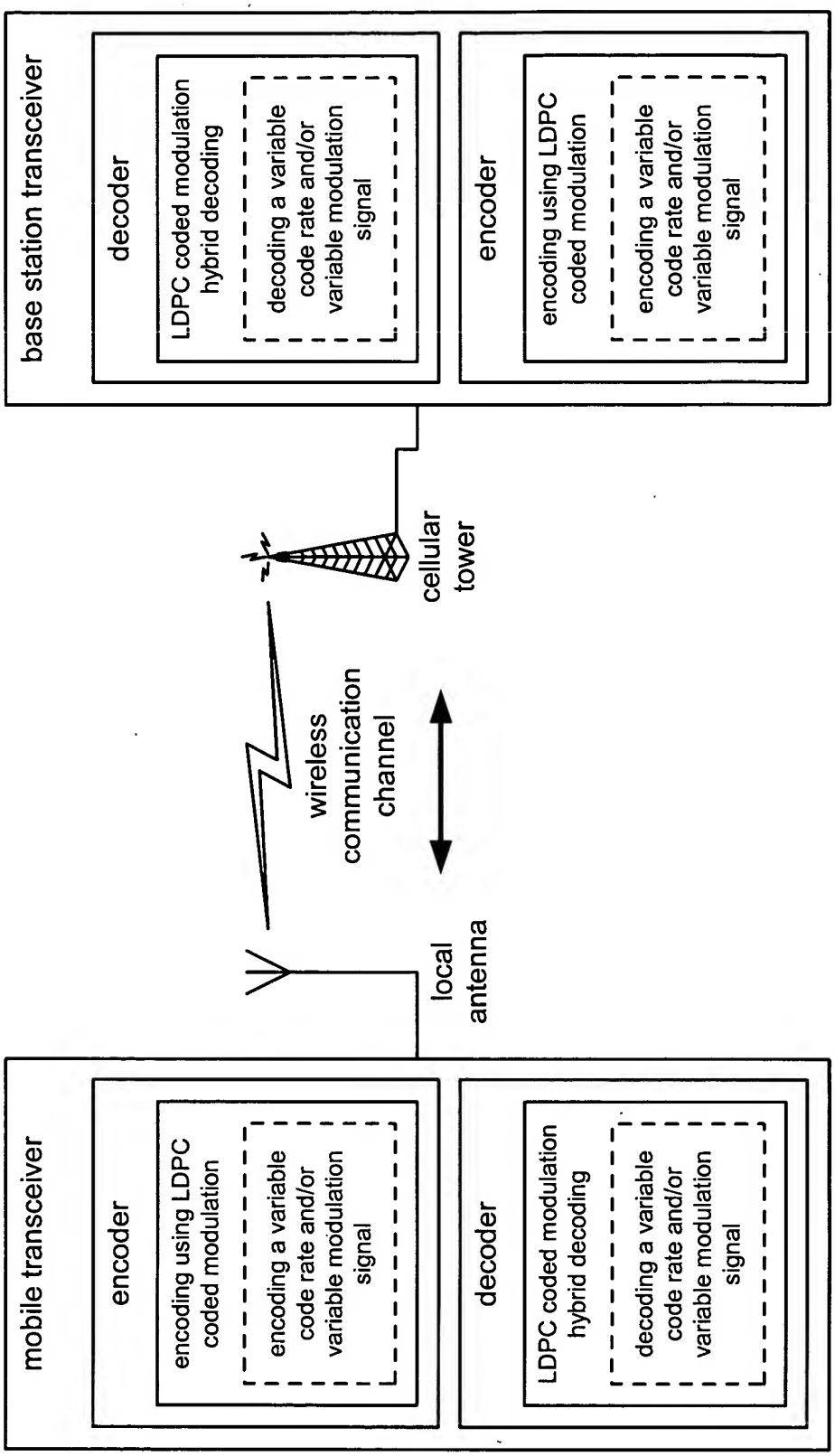
uni-directional cellular communication system

Fig. 3A



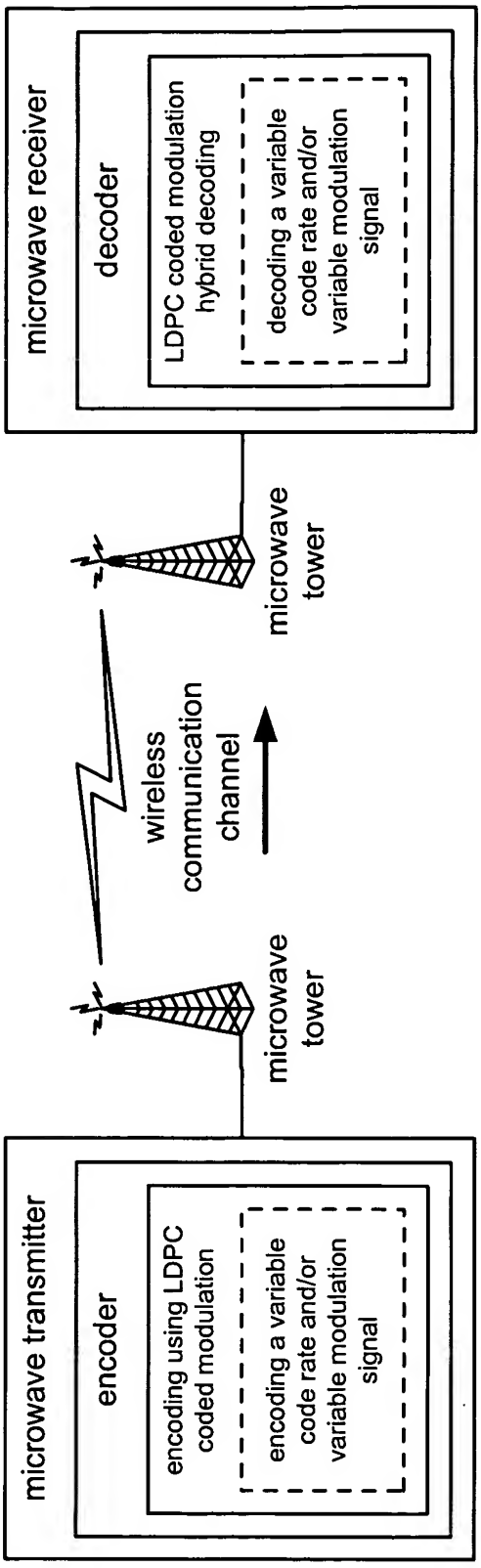
uni-directional cellular communication system

Fig. 3B



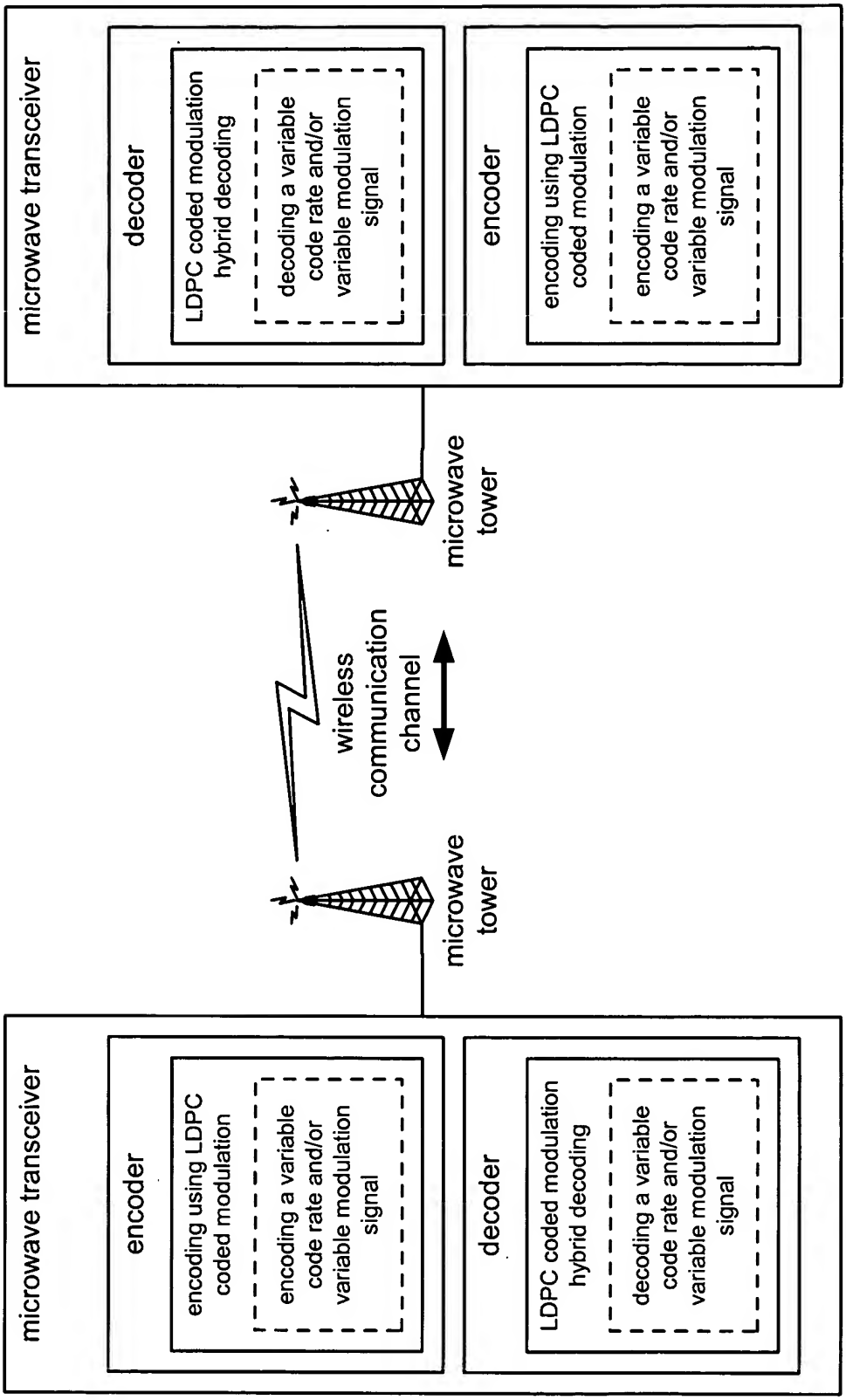
bi-directional cellular communication system

Fig. 4



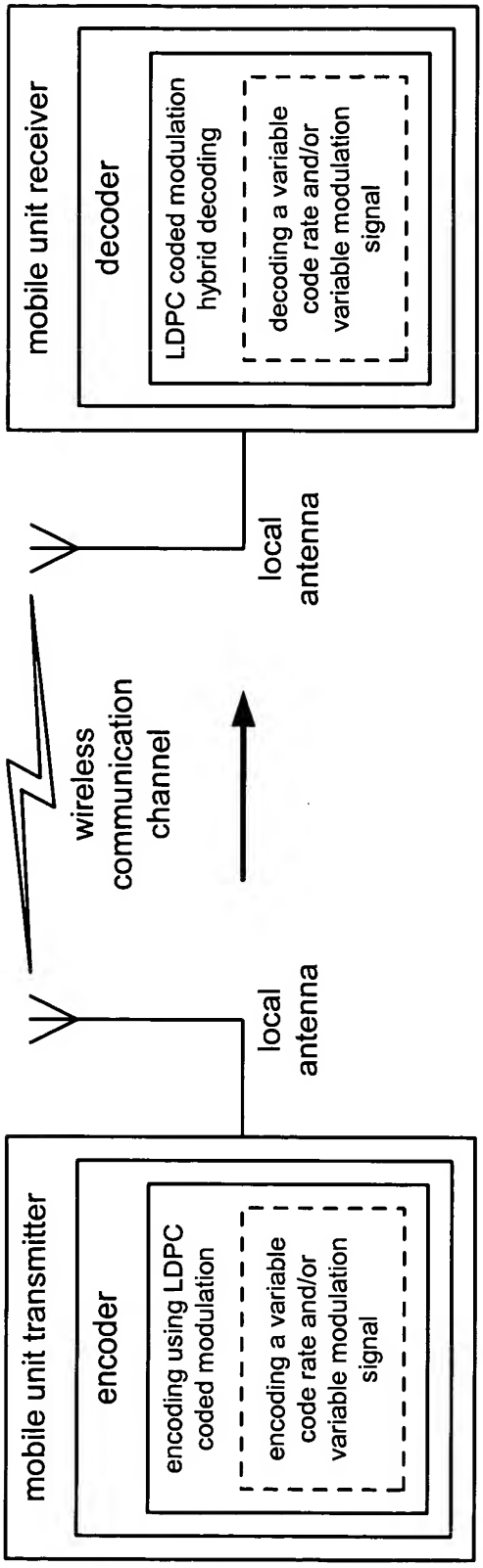
uni-directional microwave communication system

Fig. 5



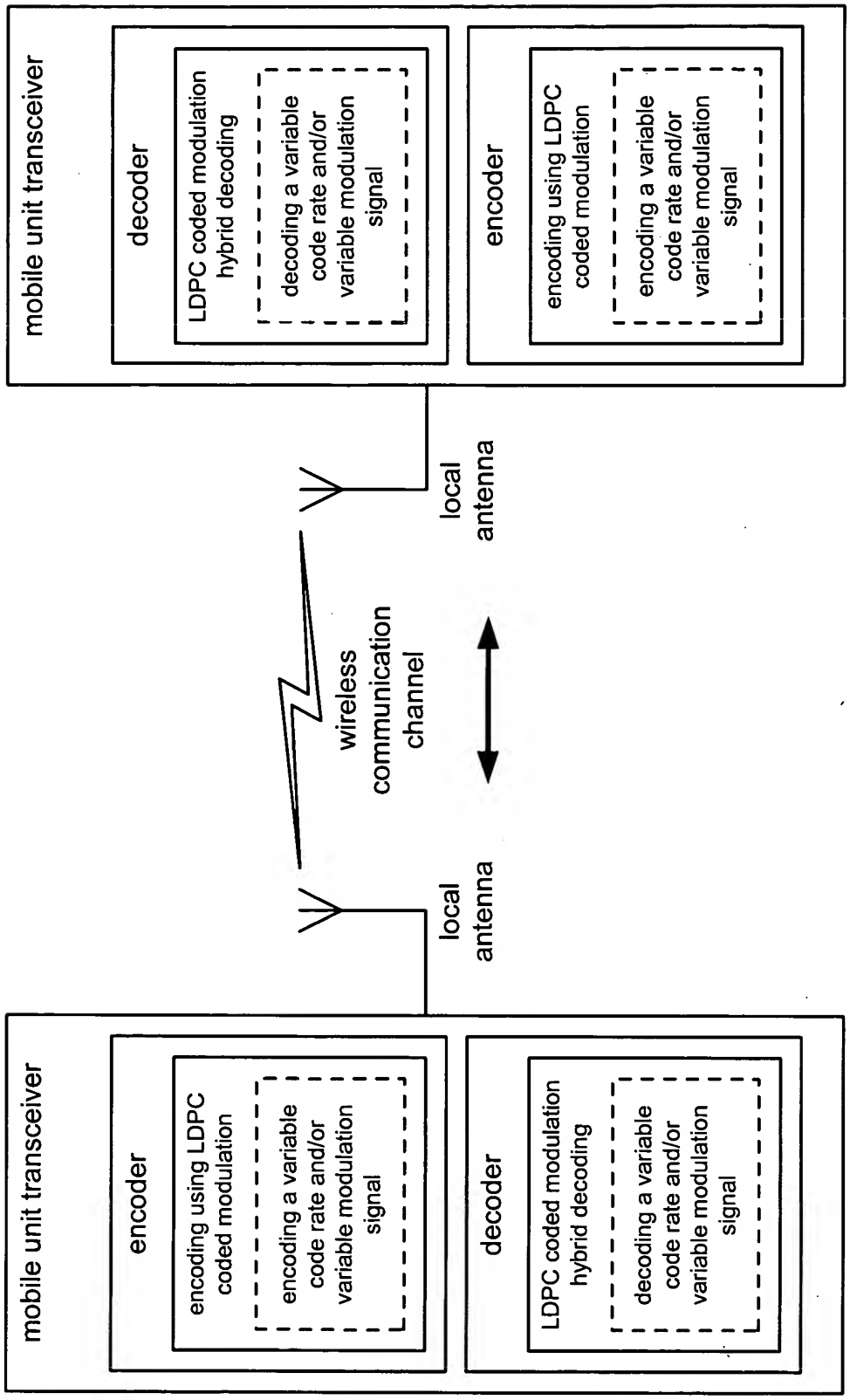
bi-directional microwave communication system

Fig. 6



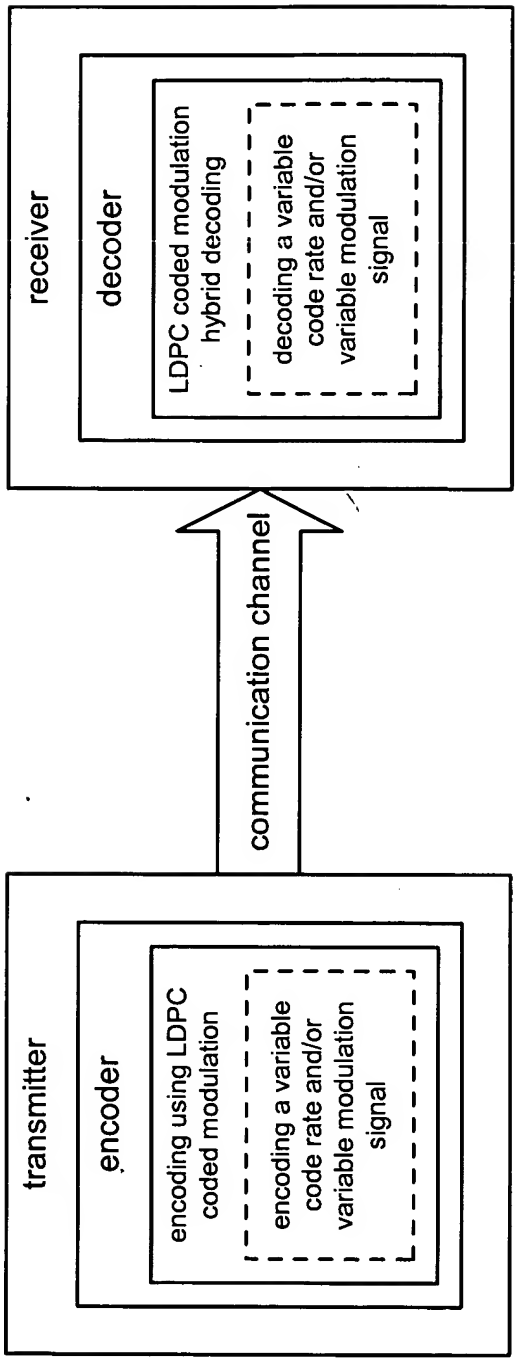
uni-directional point-to-point radio communication system

Fig. 7



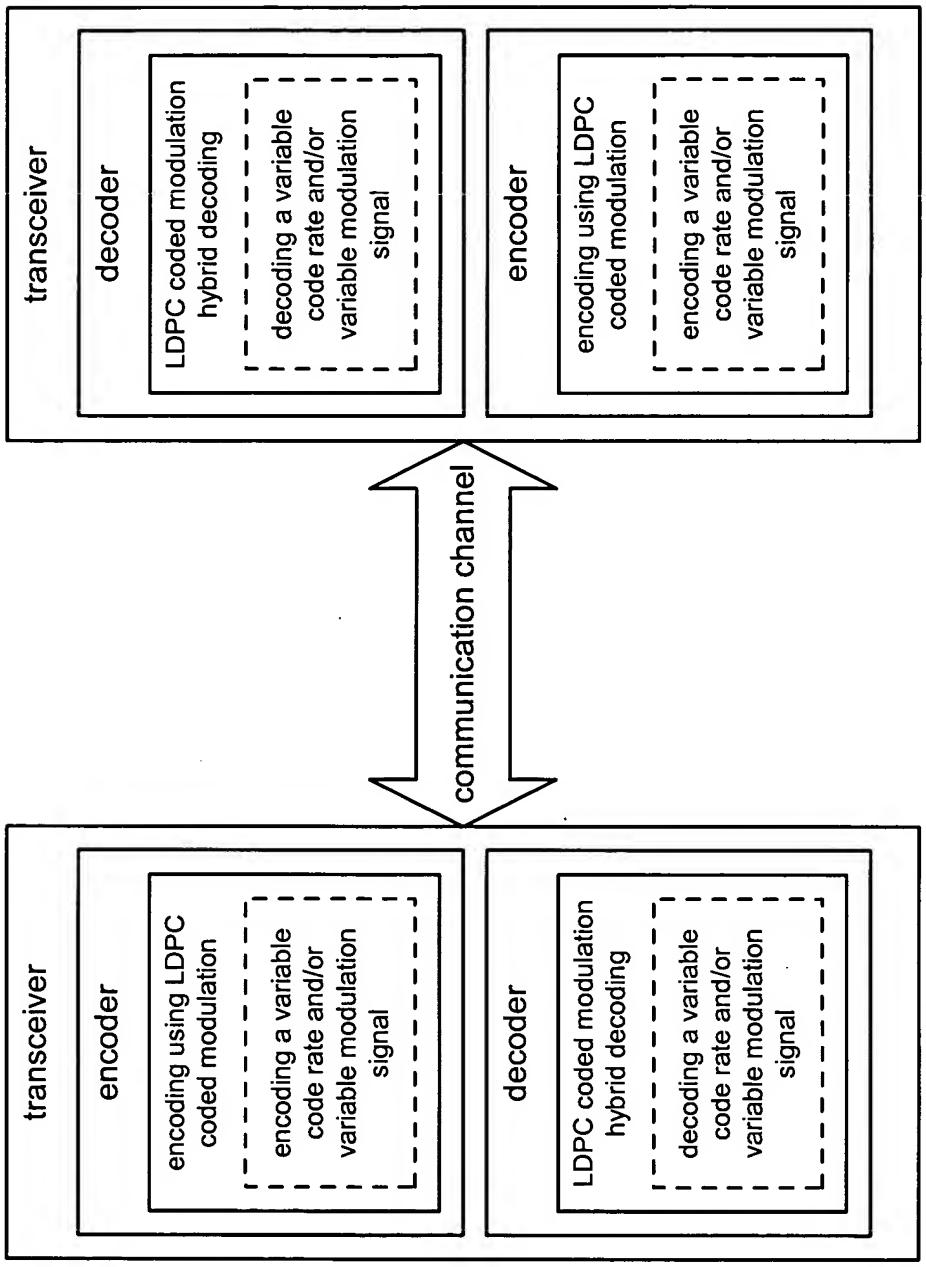
bi-directional point-to-point radio communication system

Fig. 8



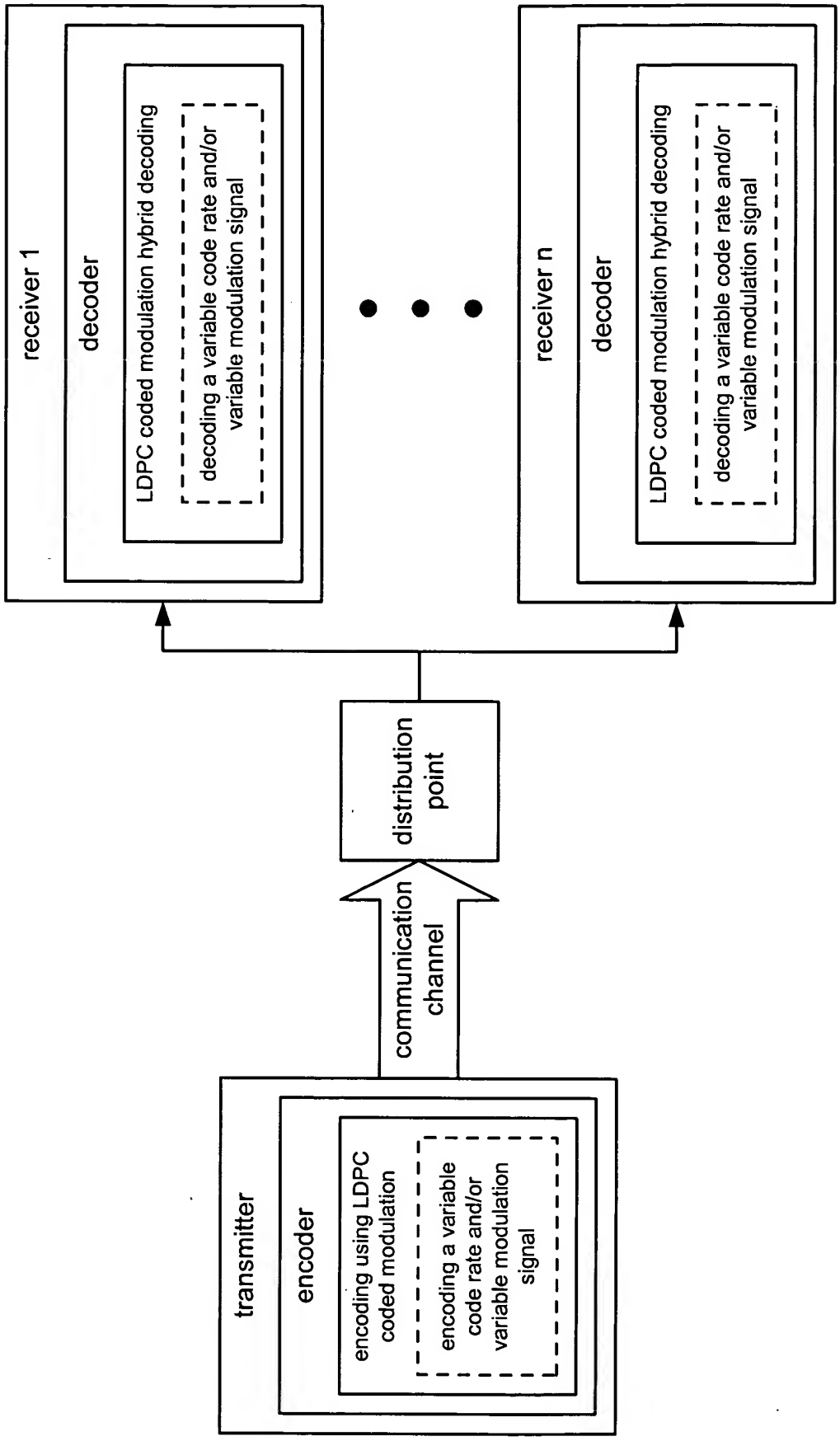
uni-directional communication system

Fig. 9



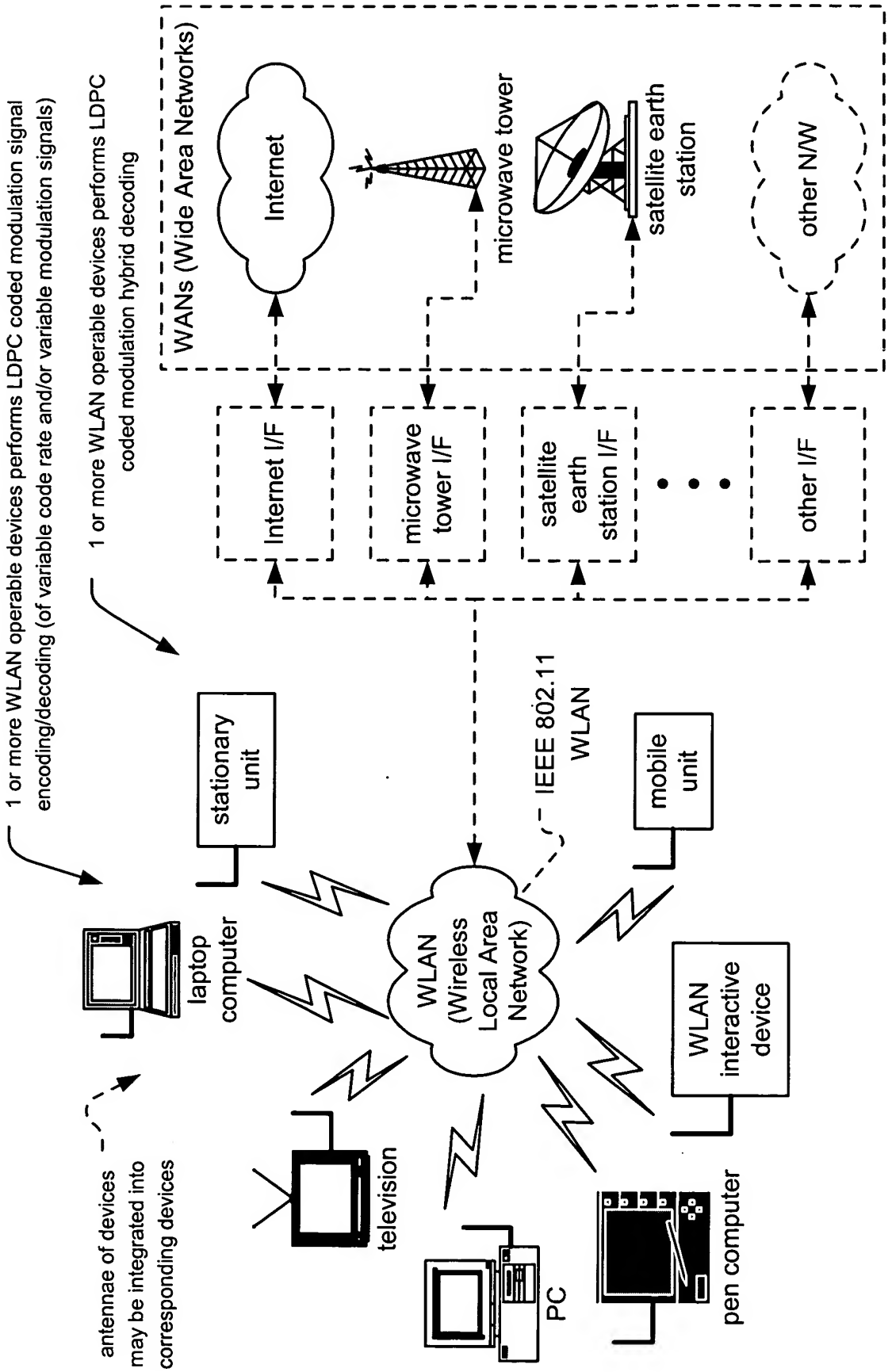
bi-directional communication system

Fig. 10



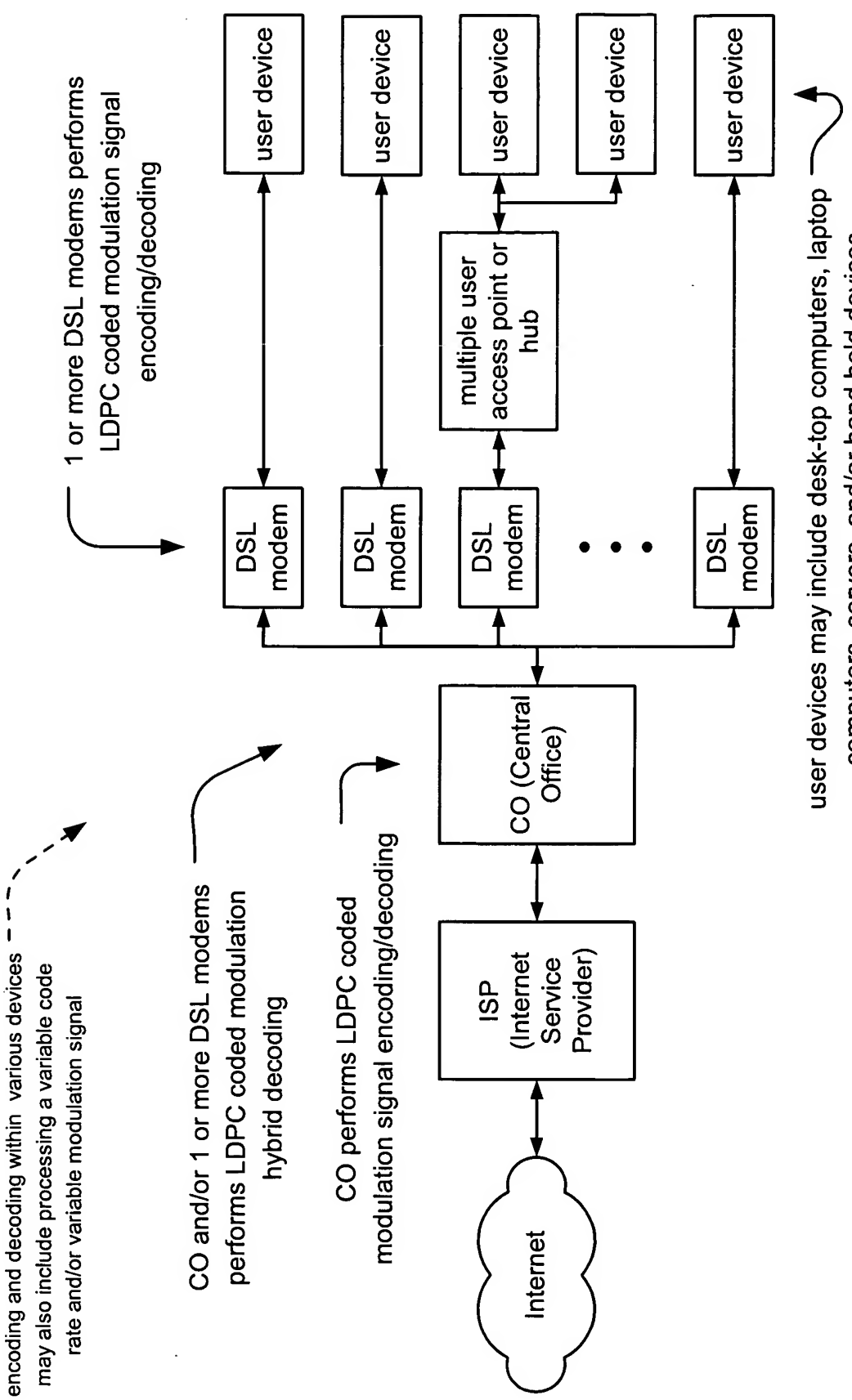
one to many communication system

Fig. 11



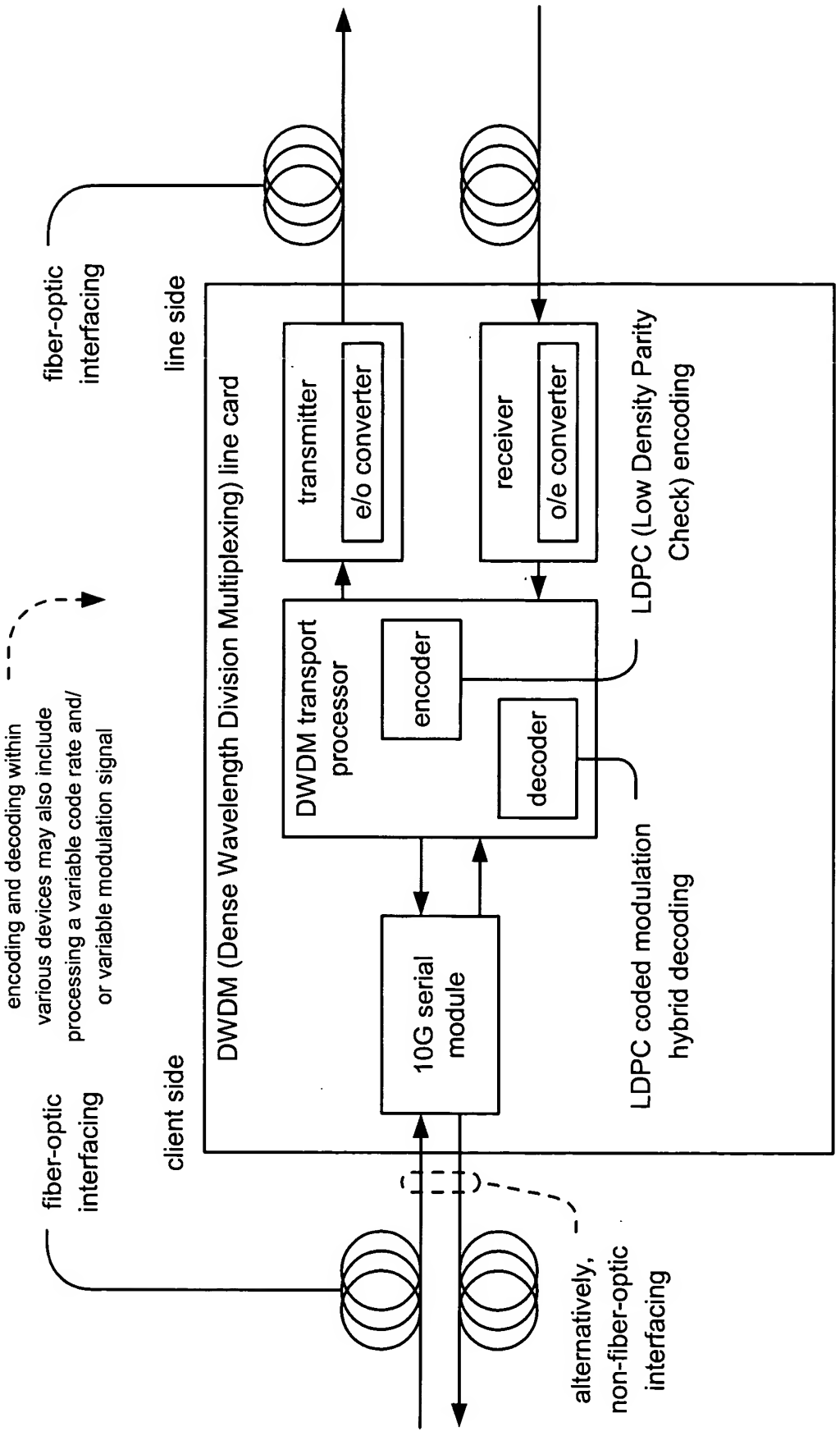
WLAN (Wireless Local Area Network) communication system

Fig. 12



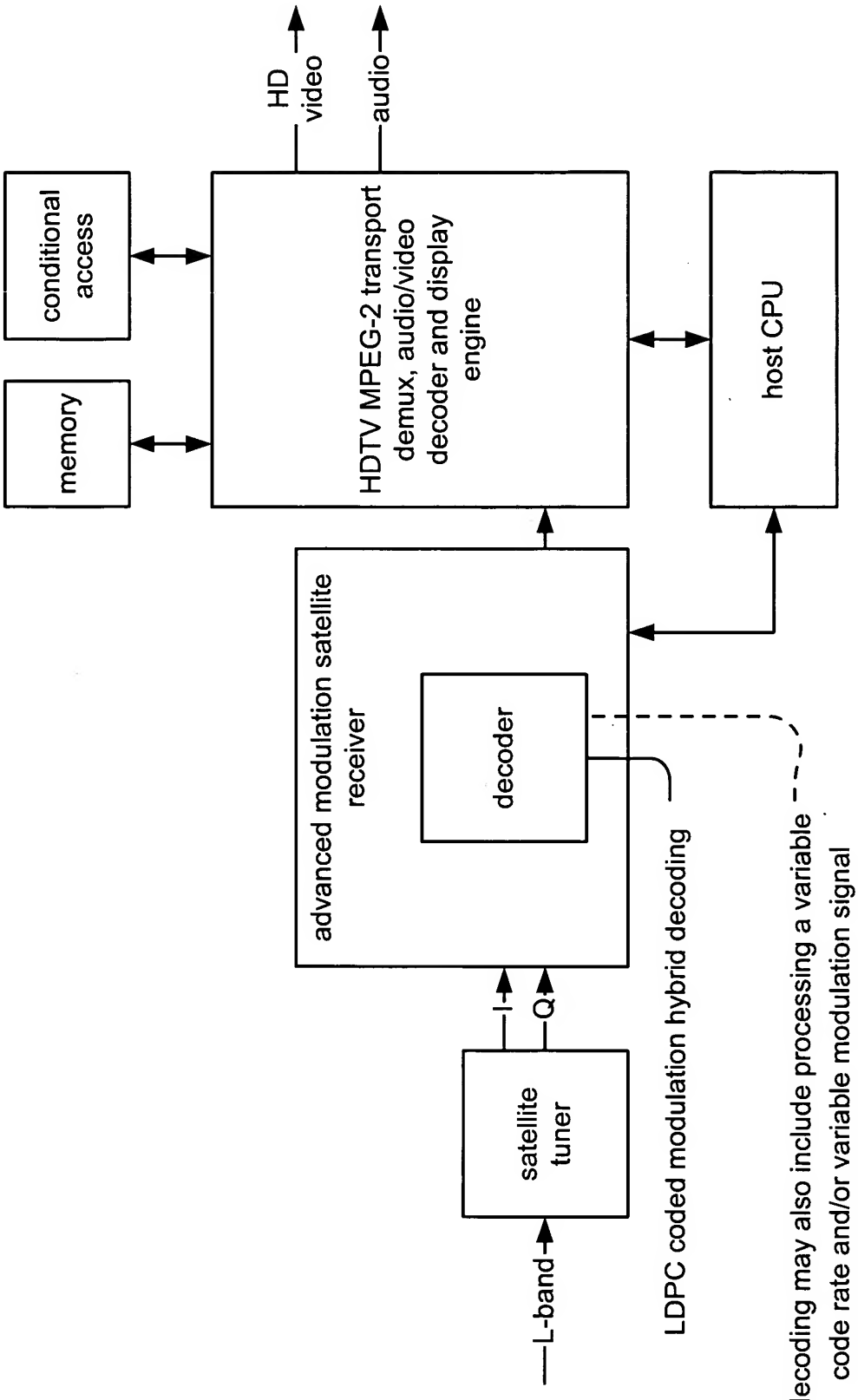
DSL (Digital Subscriber Line) communication system

Fig. 13



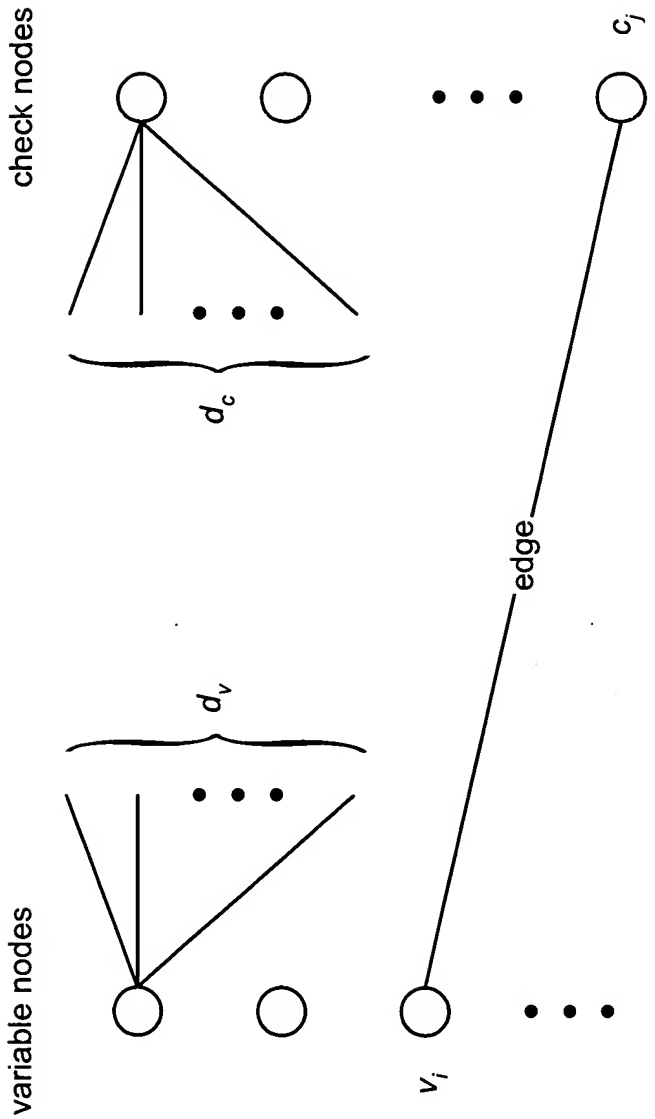
fiber-optic communication system

Fig. 14



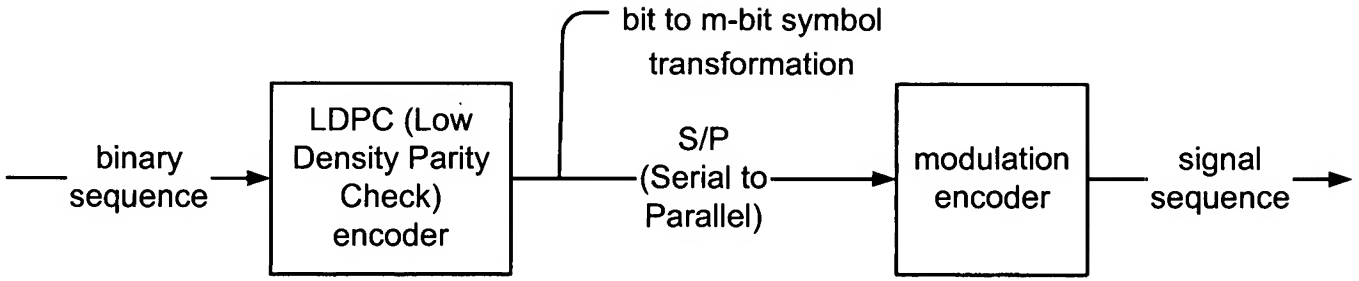
satellite receiver STB (Set Top Box) system

Fig. 15



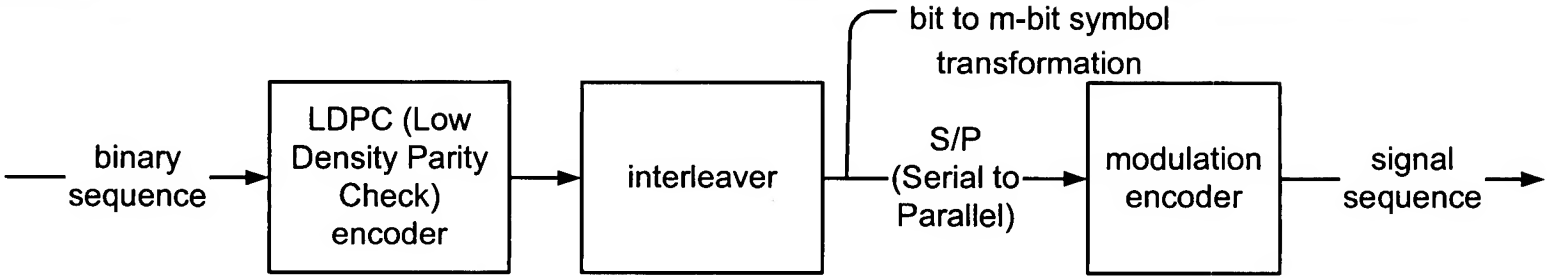
LDPC (Low Density Parity Check) code bipartite graph

Fig. 16



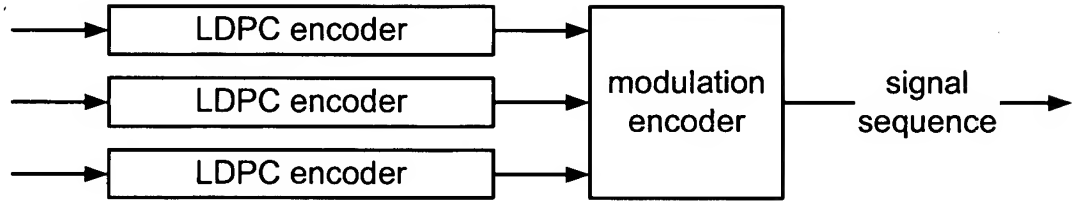
direct combining of LDPC (Low Density Parity Check) coding and modulation

Fig. 17A



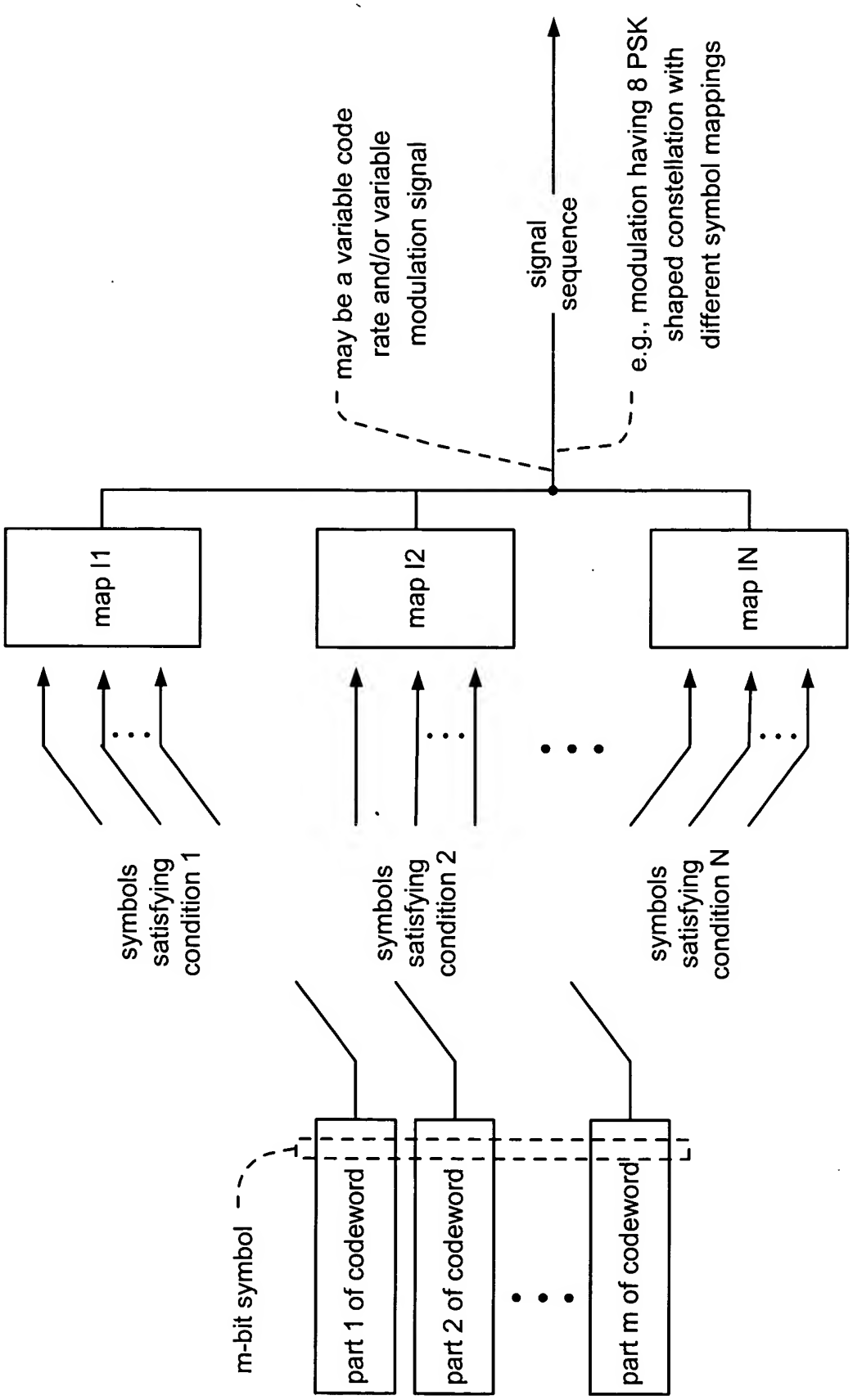
BICM (Bit Interleaved Coded Modulation)

Fig. 17B



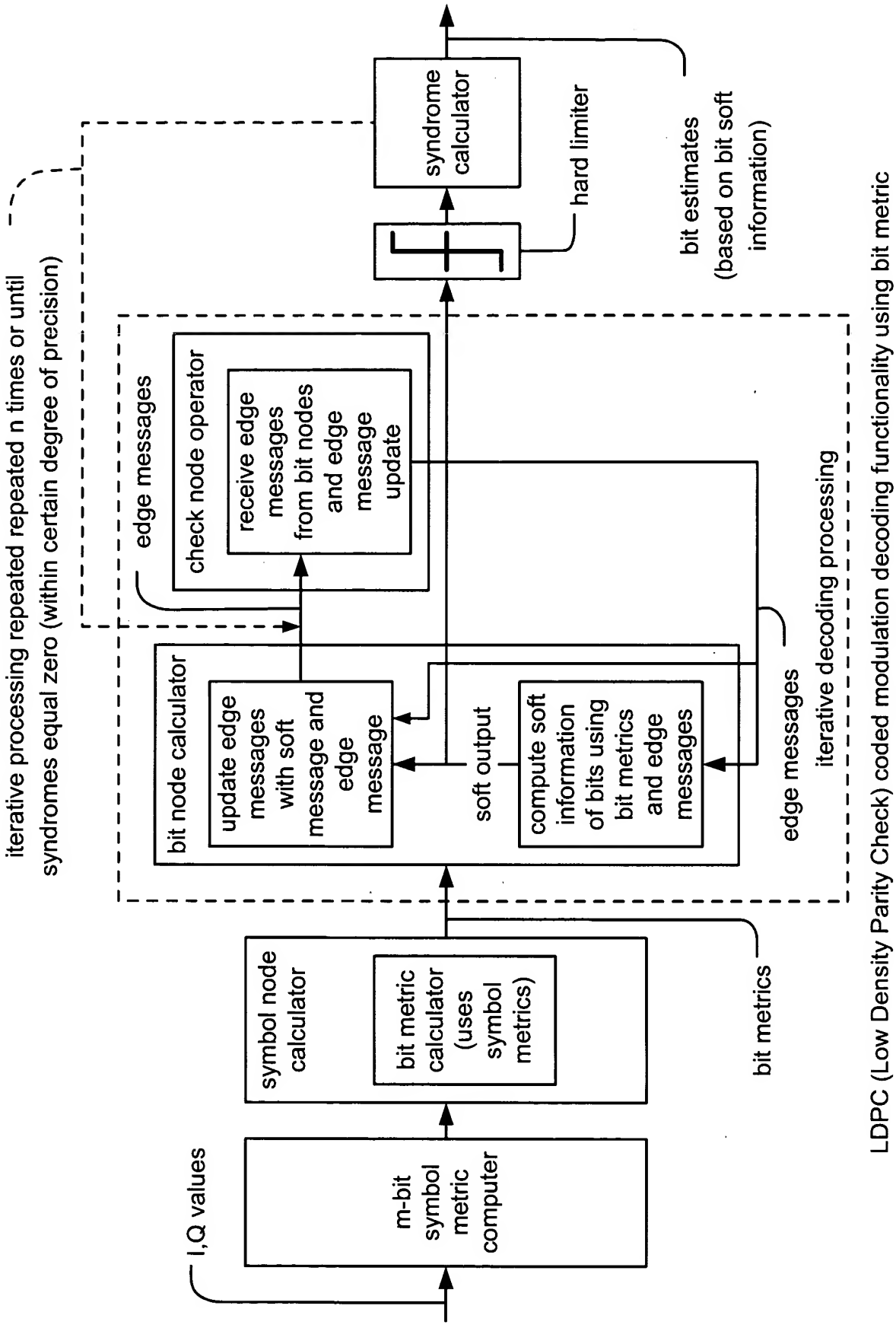
multilevel coded modulation

Fig. 17C



variable signal mapping LDPC (Low Density Parity Check) coded modulation system

Fig. 18



LDPC (Low Density Parity Check) coded modulation decoding functionality using bit metric

Fig. 19

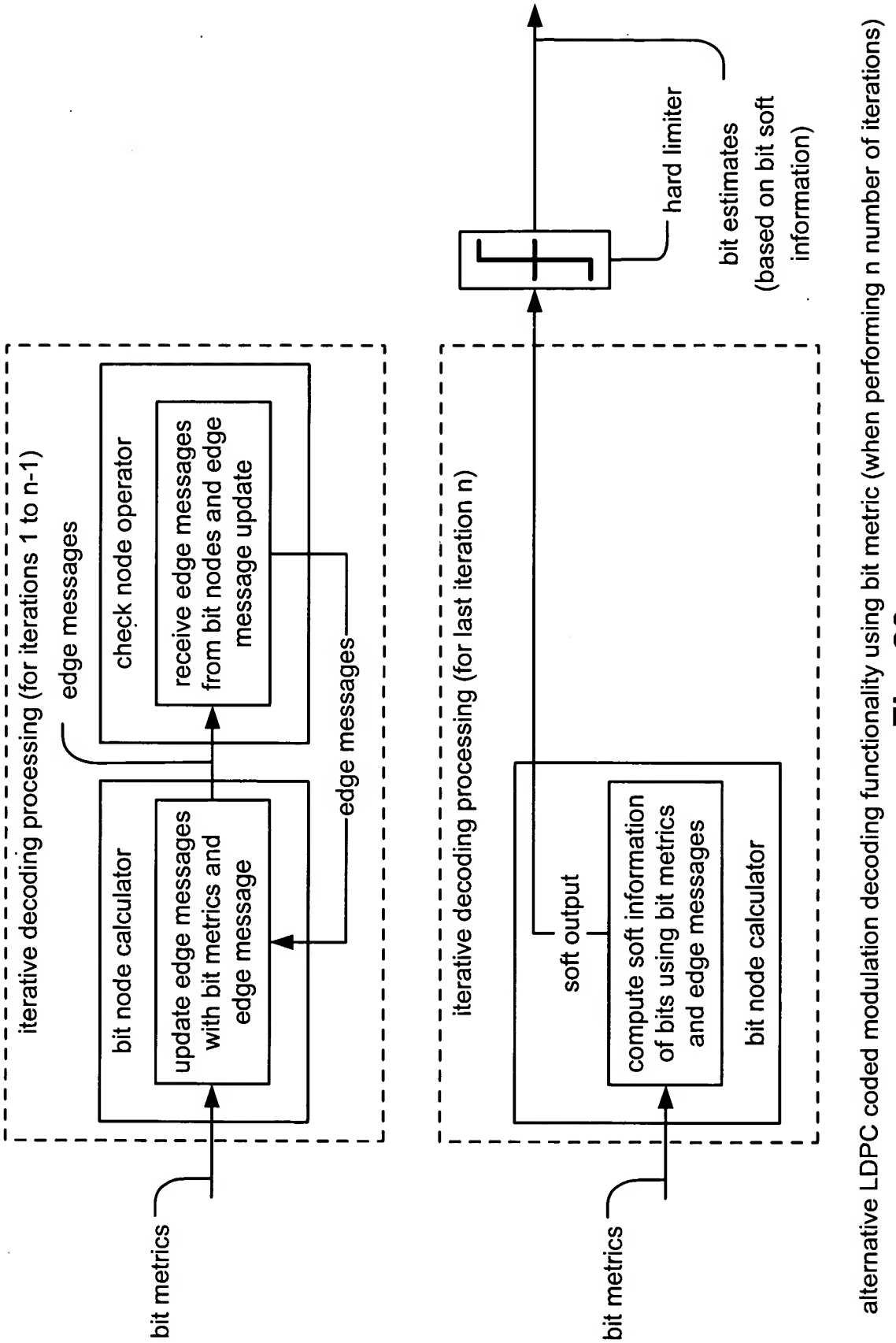
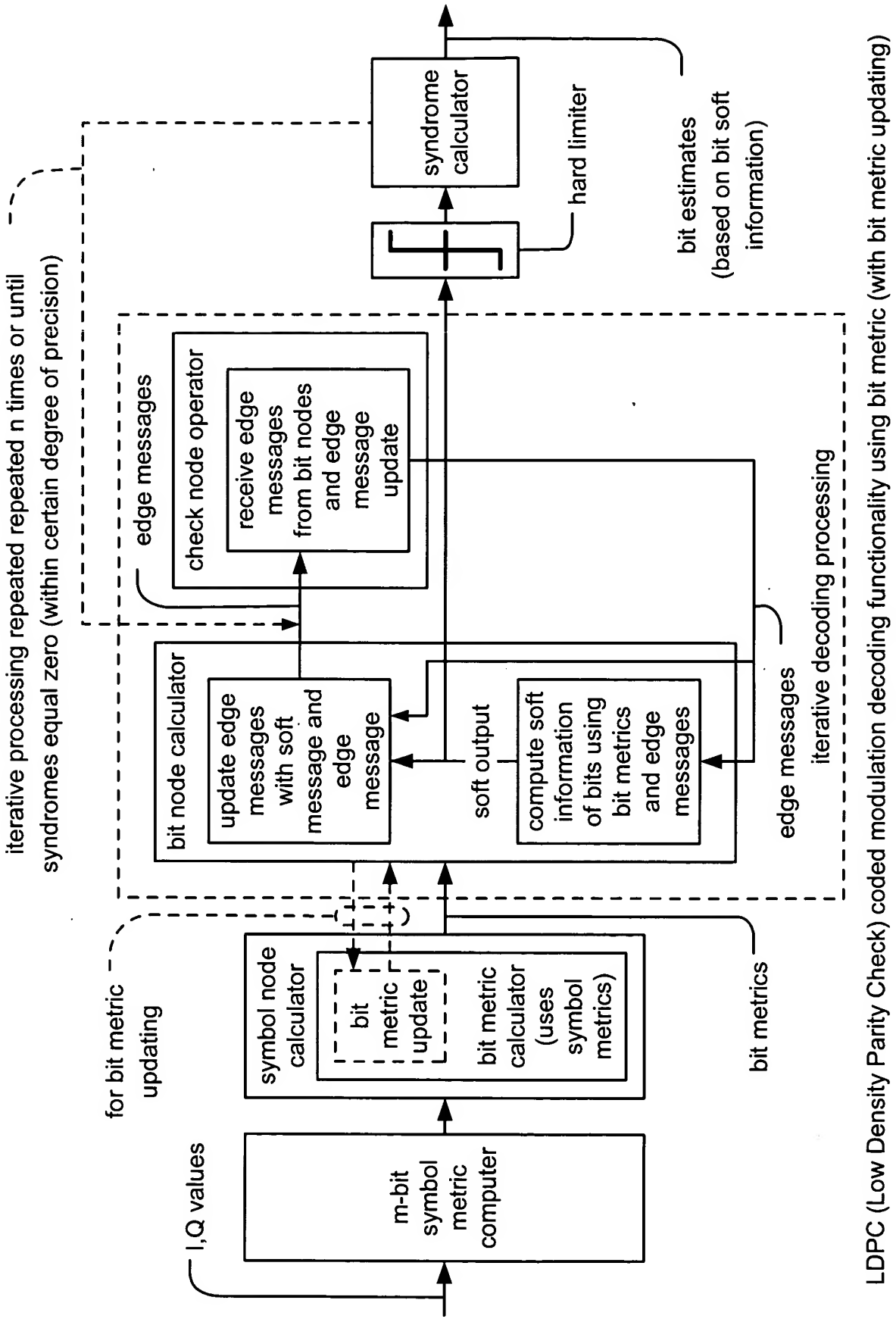


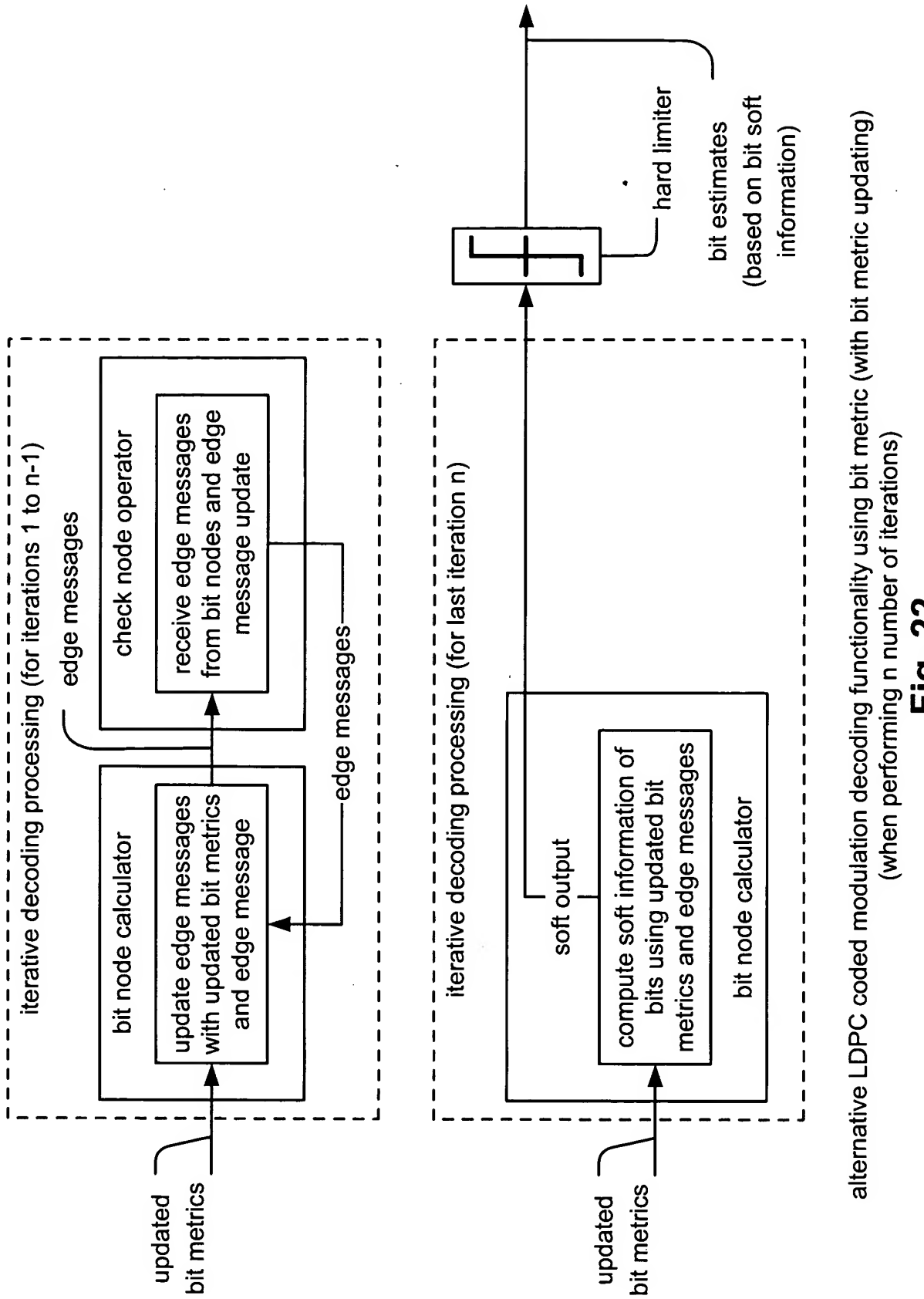
Fig. 20

alternative LDPC coded modulation decoding functionality using bit metric (when performing n number of iterations)



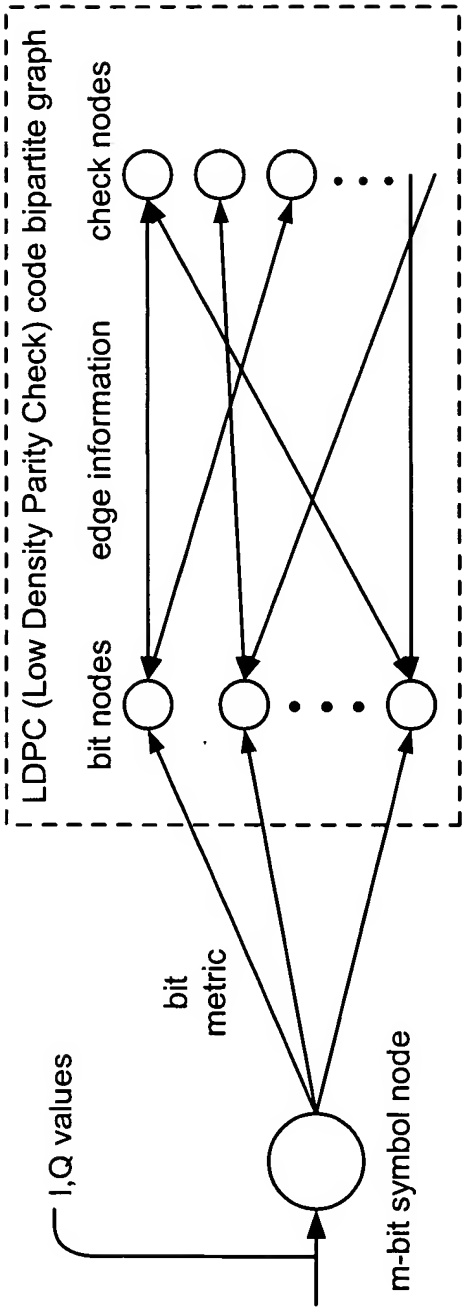
LDPC (Low Density Parity Check) coded modulation decoding functionality using bit metric (with bit metric updating)

Fig. 21



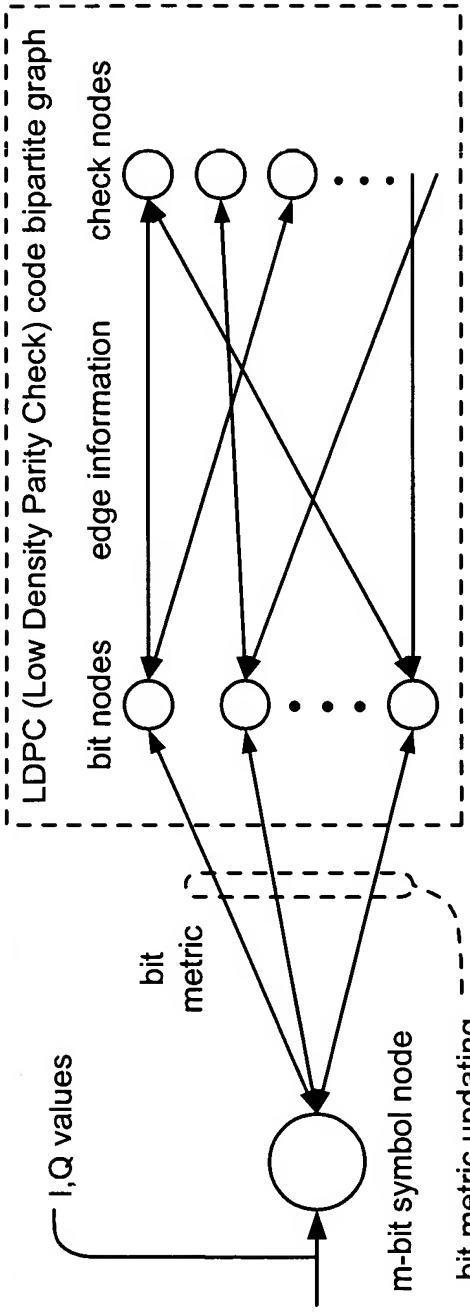
alternative LDPC coded modulation decoding functionality using bit metric (with bit metric updating) (when performing n number of iterations)

Fig. 22



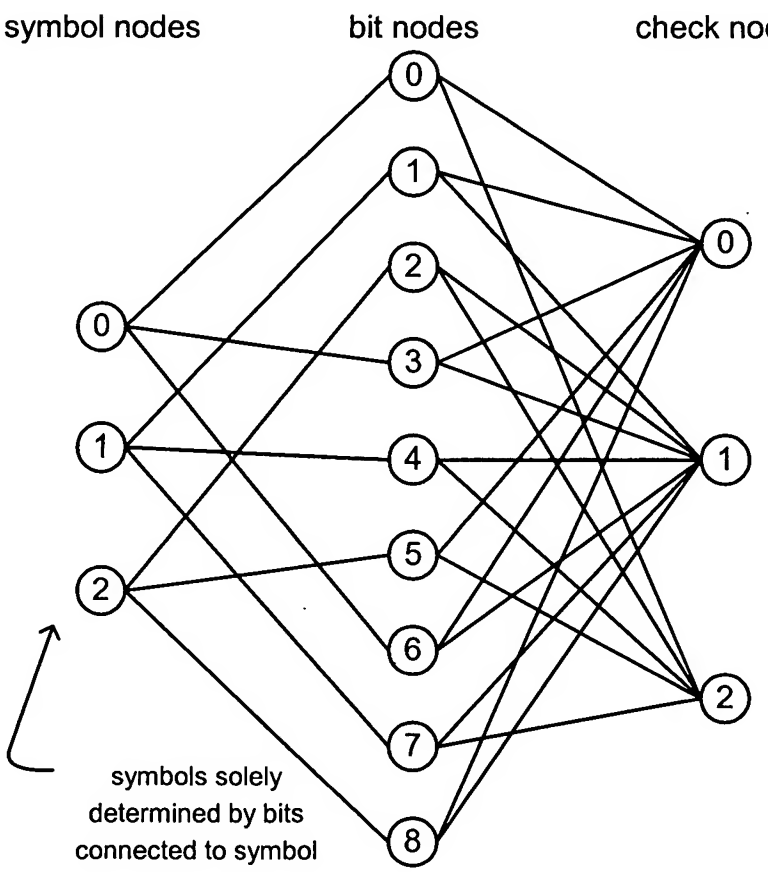
bit decoding using bit metric (shown with respect to LDPC code bipartite graph)

Fig. 23A



bit decoding using bit metric updating (shown with respect to LDPC code bipartite graph)

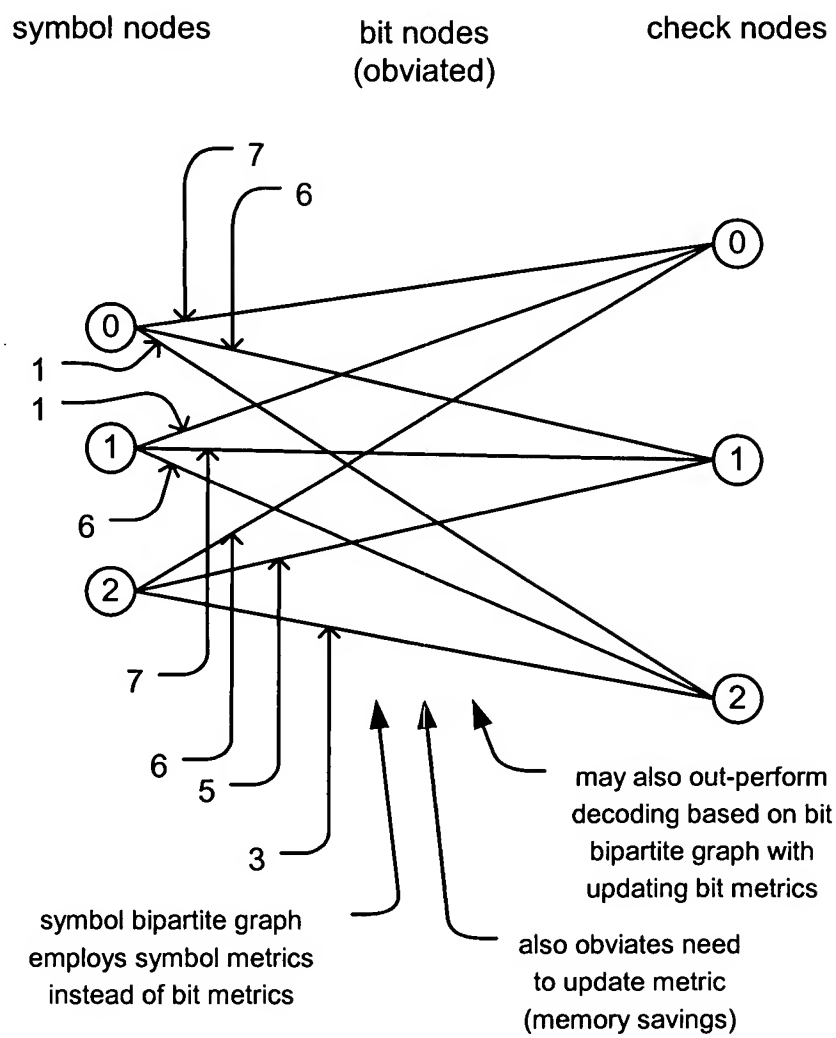
Fig. 23B



$$s_0 \leftrightarrow (b_0, b_3, b_6) \quad s_1 \leftrightarrow (b_1, b_4, b_7)$$
$$s_2 \leftrightarrow (b_2, b_5, b_8) \qquad \text{EQ 1}$$

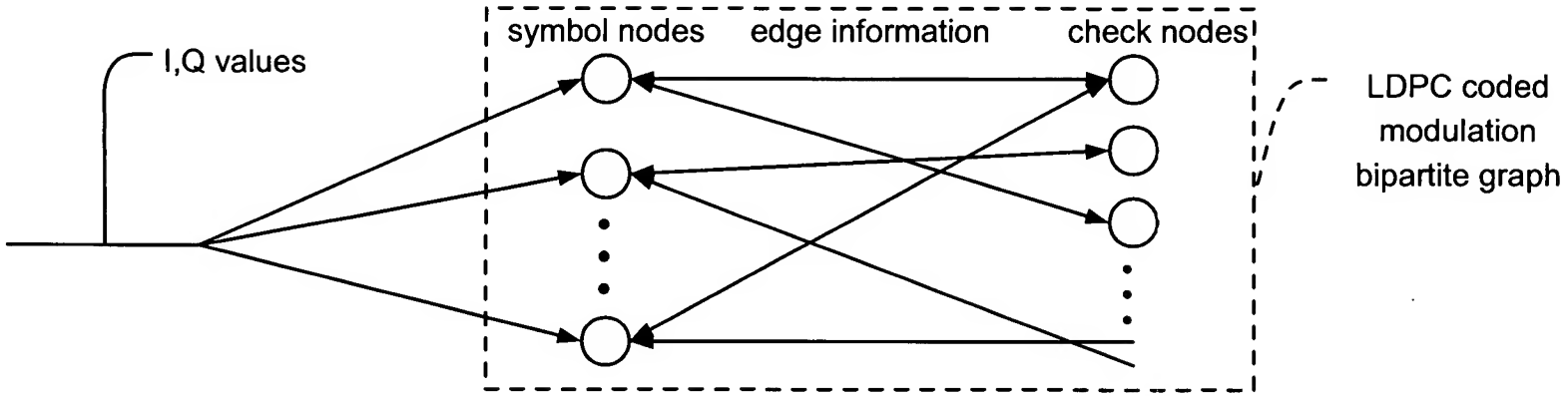
LDPC (Low Density Parity Check) coded modulation tripartite graph (or bit bipartite graph) with symbol nodes connected to bit nodes

Fig. 24A



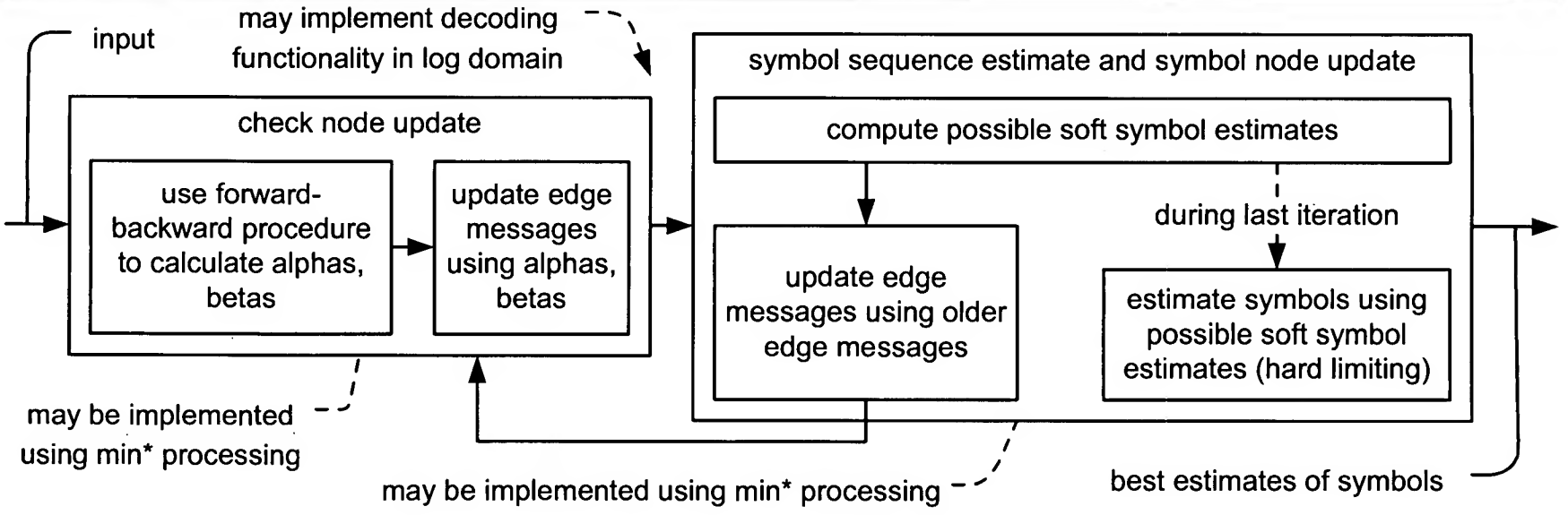
LDPC coded modulation bipartite graph (or symbol bipartite graph) with symbol nodes connected directly to check nodes (with labeled edges)

Fig. 24B



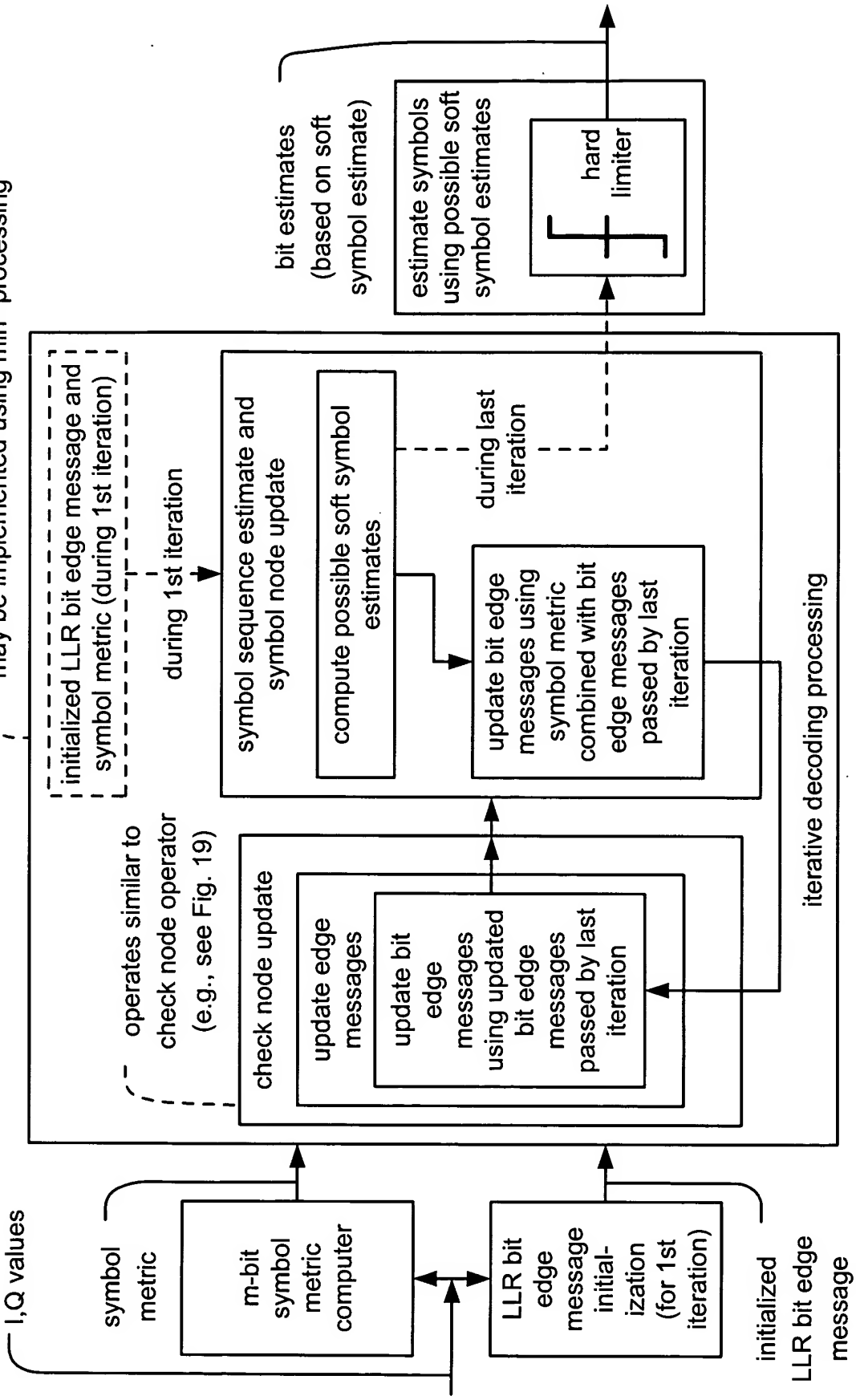
symbol decoding (shown with respect to LDPC (Low Density Parity Check) coded modulation bipartite graph)

Fig. 25A



symbol decoding functionality (supported with LDPC (Low Density Parity Check) coded modulation bipartite graph)

Fig. 25B



hybrid decoding functionality (having reduced complexity of symbol decoding) of LDPC coded modulation signals

Fig. 26

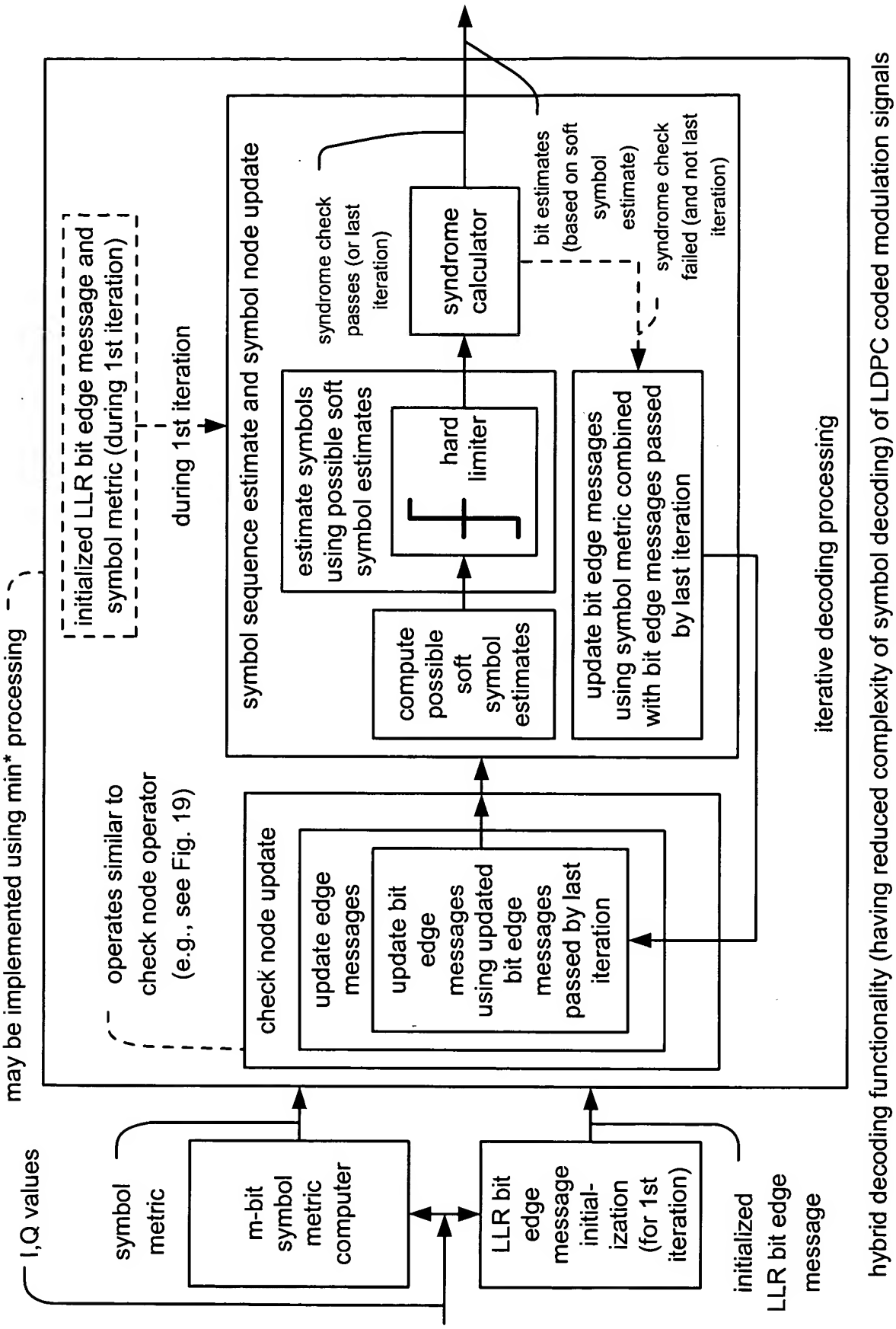
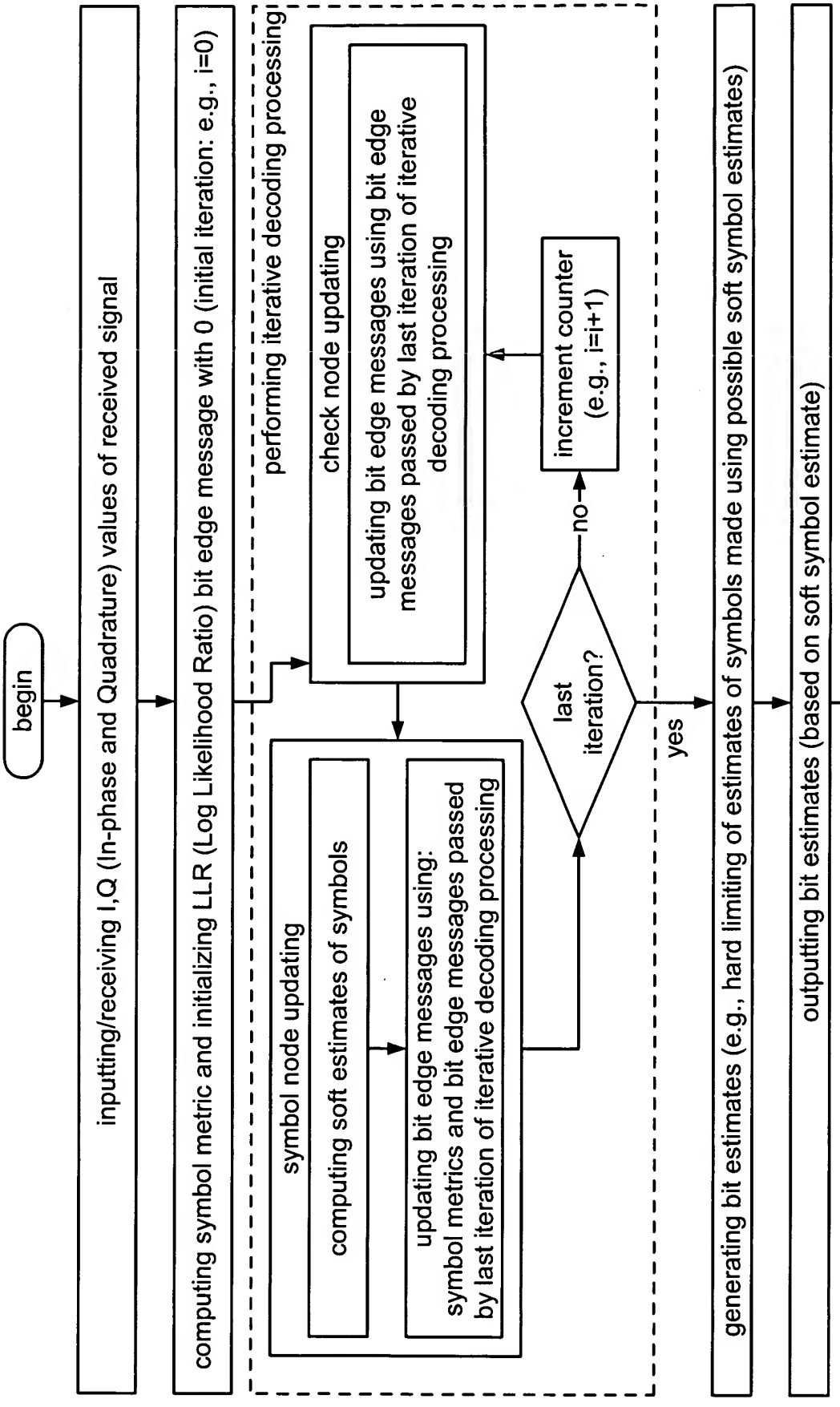


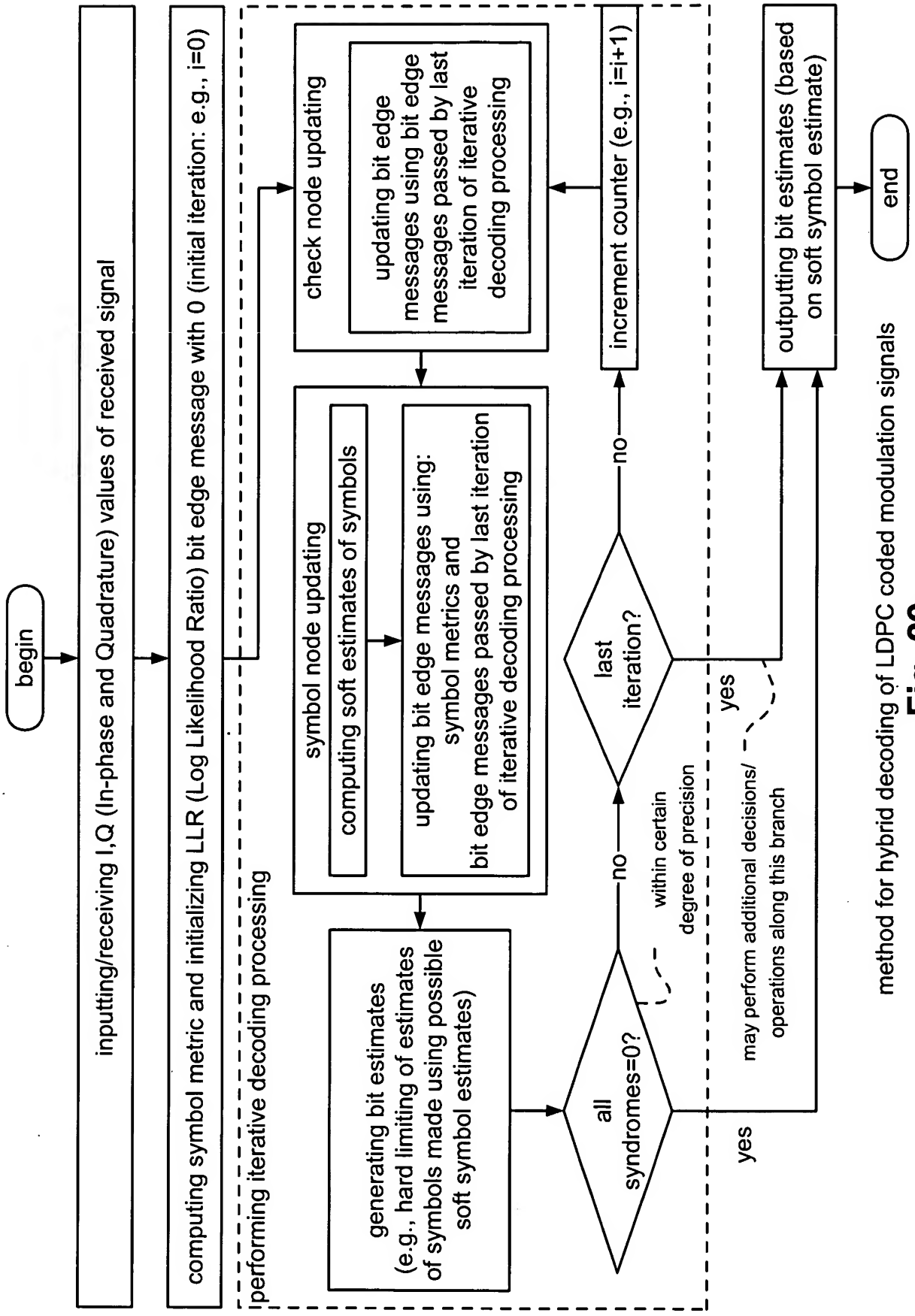
Fig. 27

hybrid decoding functionality (having reduced complexity of symbol decoding) of LDPC coded modulation signals



method for hybrid decoding of LDPC coded modulation signals

Fig. 28



method for hybrid decoding of LDPC coded modulation signals

Fig. 29

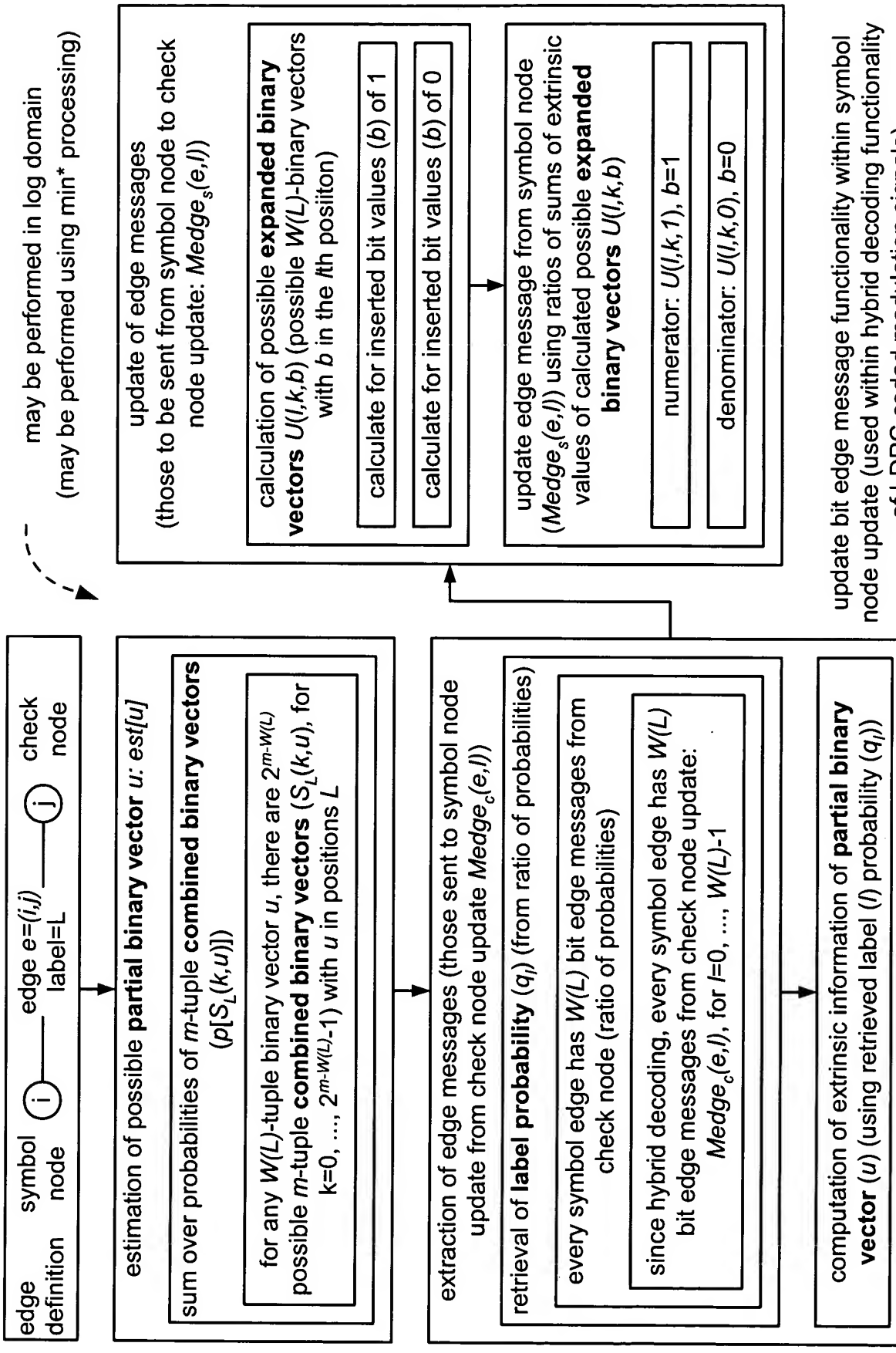
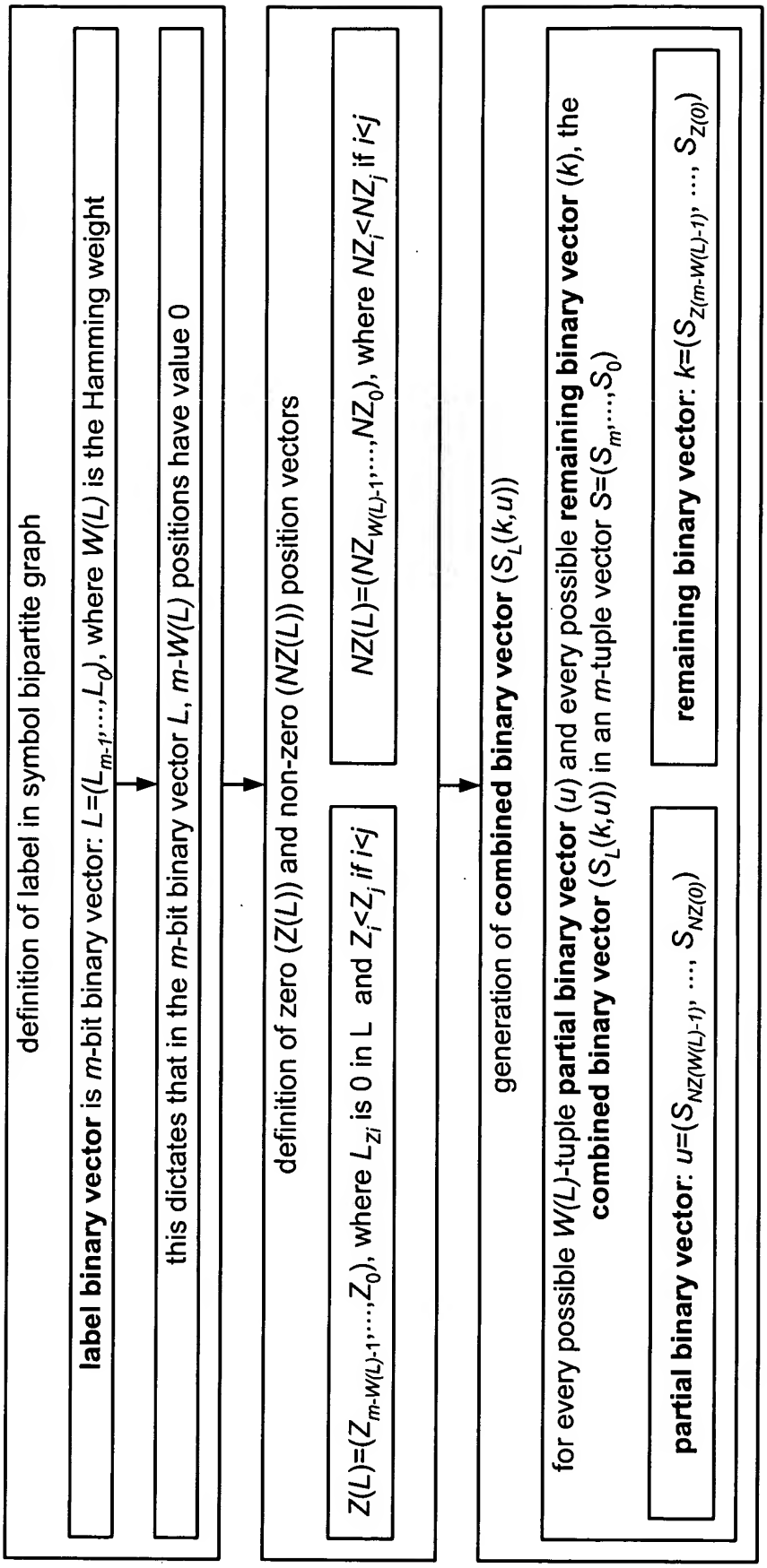
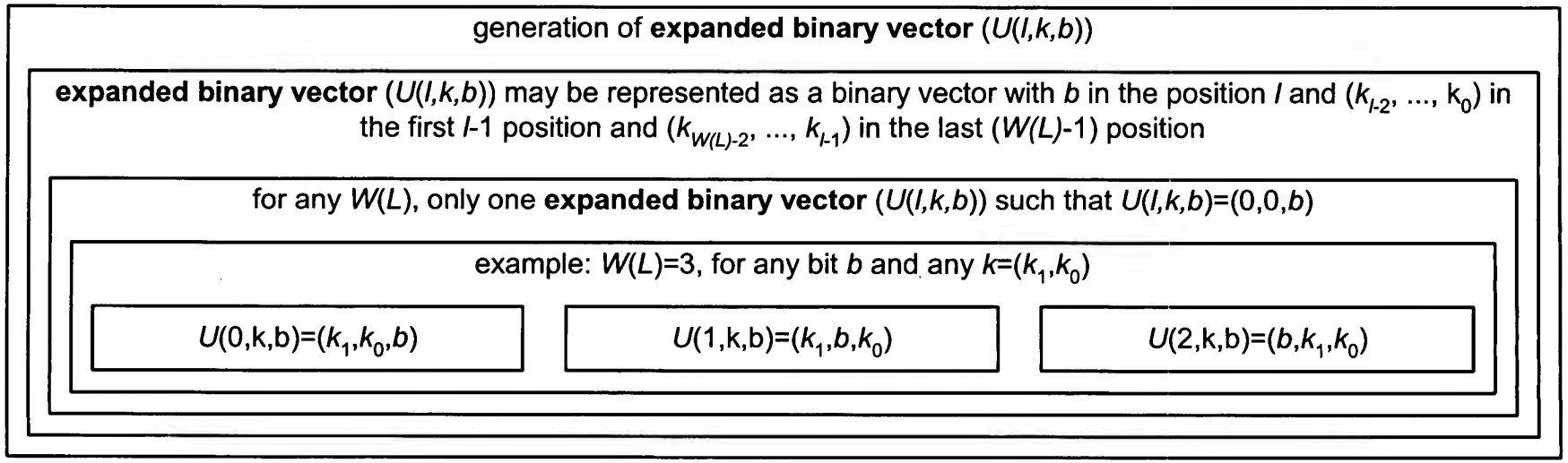

edge definition
symbol node
i
edge e=(i,j) label=L
j
check node
may be performed in log domain (may be performed using min* processing)
estimation of possible partial binary vector u: est[u]
sum over probabilities of m-tuple combined binary vectors (p[S_L(k,u)])
for any W(L)-tuple binary vector u, there are 2^(m-W(L)) possible m-tuple combined binary vectors (S_L(k,u), for k=0, ..., 2^(m-W(L))-1) with u in positions L
extraction of edge messages (those sent to symbol node update from check node update Medge_c(e,l))
retrieval of label probability (q_l) (from ratio of probabilities)
every symbol edge has W(L) bit edge messages from check node (ratio of probabilities)
since hybrid decoding, every symbol edge has W(L) bit edge messages from check node update: Medge_c(e,l), for l=0, ..., W(L)-1
computation of extrinsic information of partial binary vector (u) (using retrieved label (l) probability (q_l))
update of edge messages (those to be sent from symbol node to check node update: Medge_s(e,l))
calculation of possible expanded binary vectors U(l,k,b) (possible W(L)-binary vectors with b in the lth posiiton)
calculate for inserted bit values (b) of 1
calculate for inserted bit values (b) of 0
update edge message from symbol node (Medge_s(e,l)) using ratios of sums of extrinsic values of calculated possible expanded binary vectors U(l,k,b)
numerator: U(l,k,1), b=1
denominator: U(l,k,0), b=0
update bit edge message functionality within symbol node update (used within hybrid decoding functionality of LDPC coded modulation signals)

Fig. 30



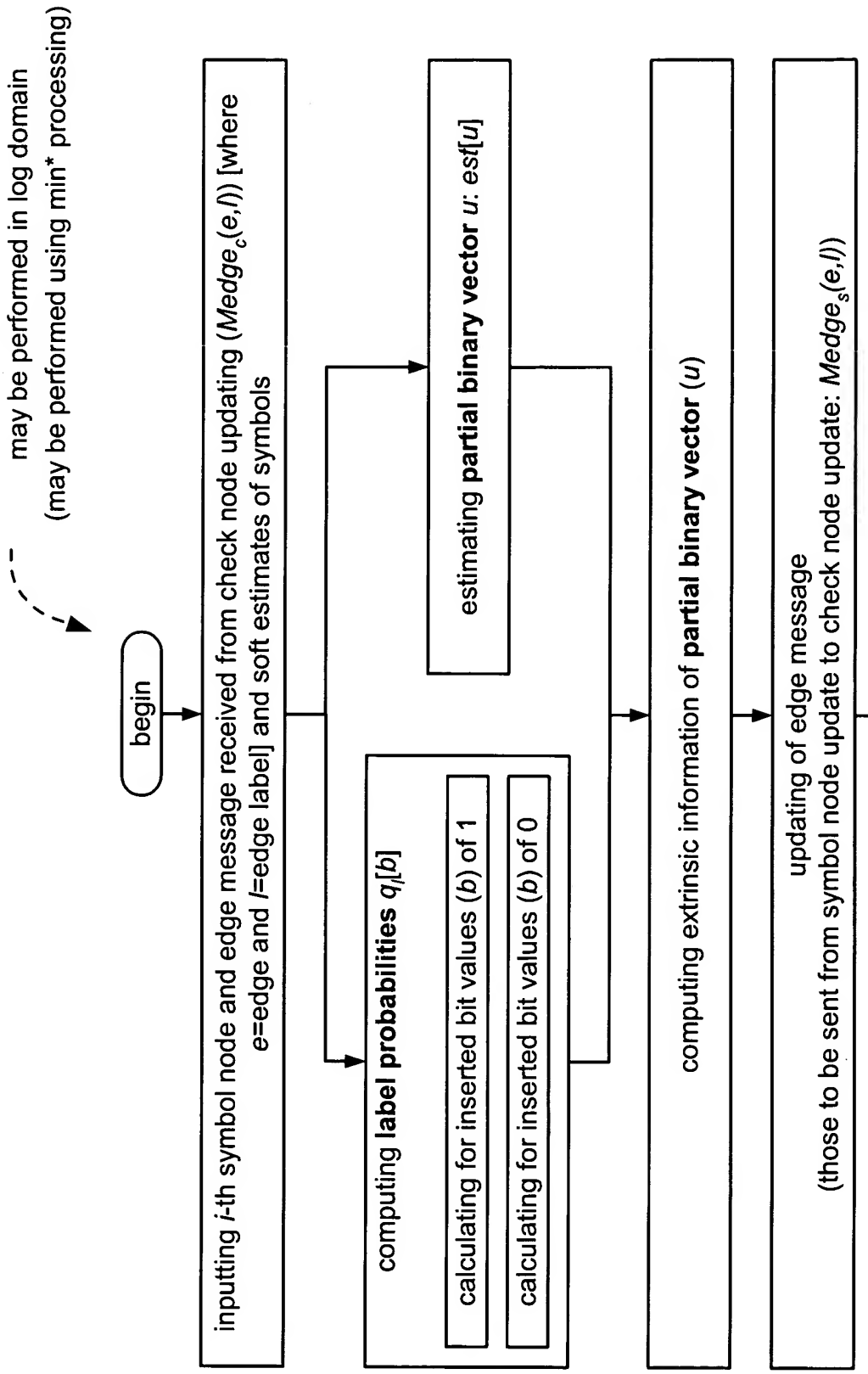
combined binary vector generation

Fig. 31



expanded binary vector generation

Fig. 32



method for updating edge messages (within symbol node updating)

Fig. 33

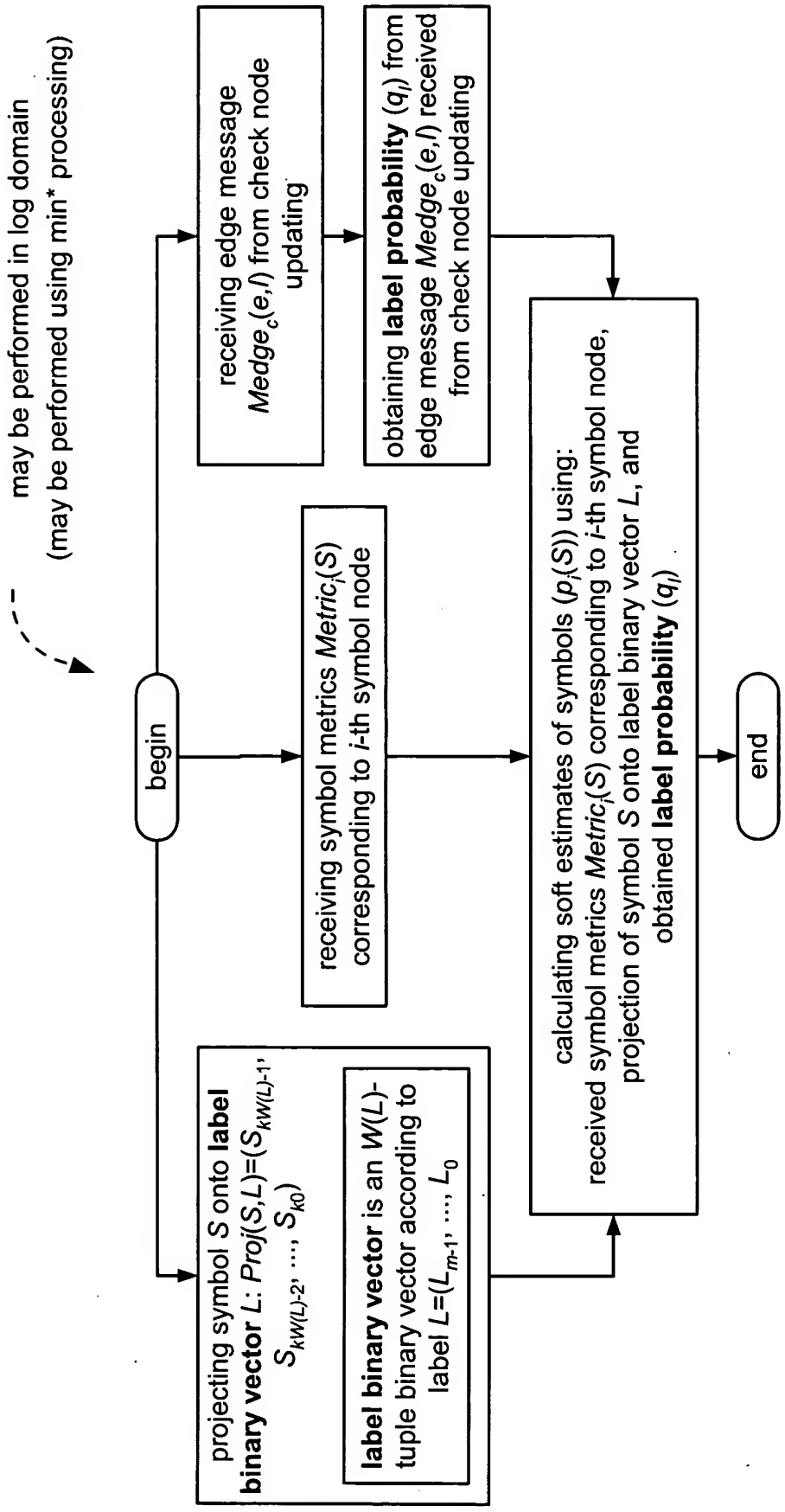


Fig. 34

method for calculating soft estimates of symbols (within symbol node updating)

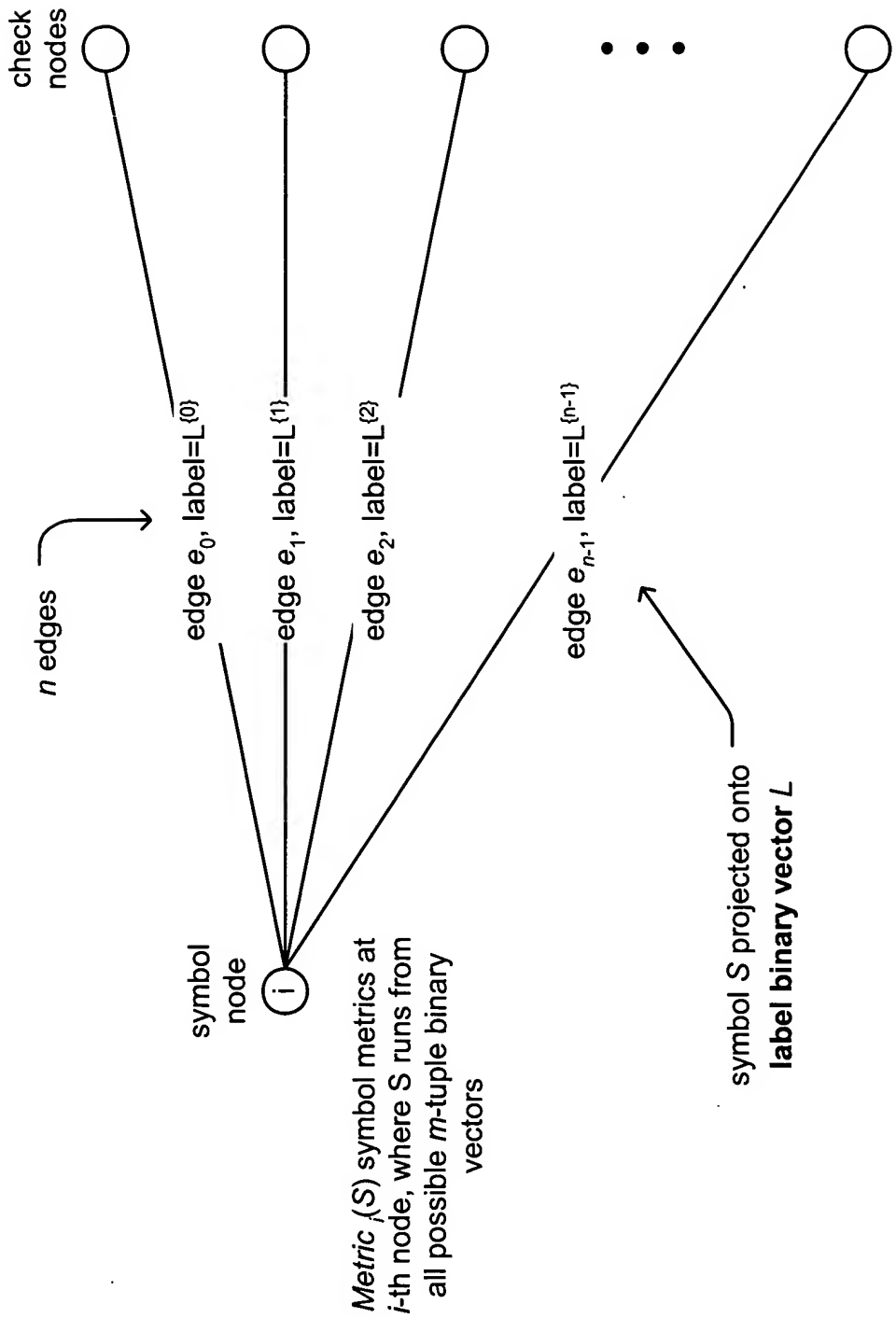

check nodes
n edges
edge e_0, label=$L^{\{0\}}$
edge e_1, label=$L^{\{1\}}$
edge e_2, label=$L^{\{2\}}$
edge e_{n-1}, label=$L^{\{n-1\}}$
symbol node
i
Metric $_i$(S) symbol metrics at i-th node, where S runs from all possible m-tuple binary vectors
symbol S projected onto label binary vector L
projection of symbol onto label binary vector

Fig. 35

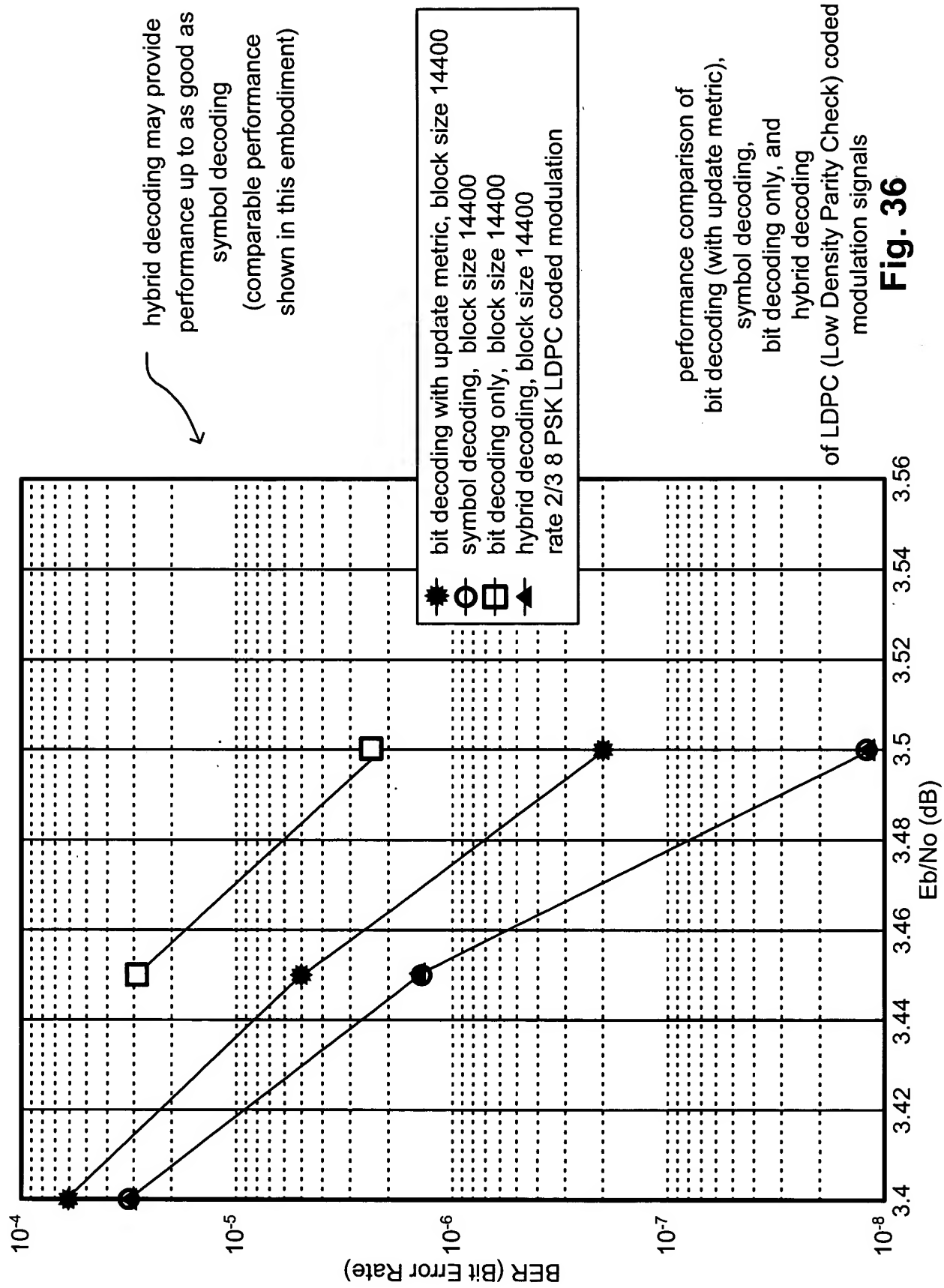

hybrid decoding may provide performance up to as good as symbol decoding (comparable performance shown in this embodiment)
bit decoding with update metric, block size 14400
symbol decoding, block size 14400
bit decoding only, block size 14400
hybrid decoding, block size 14400
rate 2/3 8 PSK LDPC coded modulation
performance comparison of bit decoding (with update metric), symbol decoding, bit decoding only, and hybrid decoding of LDPC (Low Density Parity Check) coded modulation signals
BER (Bit Error Rate)
10-4
10-5
10-6
10-7
10-8
3.4
3.42
3.44
3.46
3.48
3.5
3.52
3.54
3.56
Eb/No (dB)

Fig. 36